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Incorporating Aboriginal Peoples' Values into Measures of Economic Sustainability: The Case of the Heart Lake First Nation

by

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Abstract

Sustainability has been assessed and measured at different scales (national, regional and global) and in different aspects (environmental, economic, social and institutional). Studies relating sustainability with Aboriginal communities have been rarely done. This thesis is a contribution to the literature of measuring economic sustainability by attempting to link a component of economic value that is important to Aboriginal people, traditional hunting activities, with conventional resource accounts. The study focuses on the Heart Lake First Nation's traditional area.

This research developed natural resource accounts for forest and energy resources, and measured impacts on traditional hunting activities, on the traditional lands. Resource accounts were simulated for future years and results are discussed relative to the concepts of weak and strong sustainability. The results of the study suggest that there is evidence of sustainable resource use in the area, but are subject to a number of caveats and future research issues.

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1.0. Introduction

With the growth of global human population and the development of higher living standards, the demand for consumptive and non-consumptive goods increases, thus putting increased pressure on natural resources. This situation has developed a growing concern and an increasing awareness of the impact of the consumption by today's generations on the current general welfare of society and on that of future generations. The question of whether society is consuming too much now has made many policy makers and the general public worry about the current state of the environment and how it might look in the future; while also being concerned about how economies can continue on their path of growth. These seemingly conflicting objectives are the basis of debate around the concept of sustainability.

Economic growth, development, environmental conservation and preservation are sometimes viewed as competing components of the concept of sustainability. The definition and measurement of sustainability, while critical for policy analysis, is hotly debated. This thesis contributes to this debate by using an economic definition of sustainability and applying it to a specific region and population, a First Nations community, to assess sustainability in that region while incorporating the traditional economic values of that particular community. [1]

Sustainability has been evaluated or assessed for different countries and regions, but typically not with a focus on a specific group of people, likely with homogeneous preferences and a traditional territory, such as First Nations (FNs). Cultural attitudes towards sustainability are to some degree inherited and shaped by the course of one's

[1] First Nations are those recognized by the Canadian government as Indians (bands), Metis, and Aboriginal people.

history (Toman, et al., 1995). Aboriginal people in Canada have constitutional rights that could be interpreted as being required to provide them with a degree of sustainability. However, this has not been measured in an economic framework to the best of our knowledge.

Everyday decisions made by Aboriginal people and small forest-based communities have implications on resource use. There is a need to effectively embody the values held by Aboriginal people in the decision-making processes and for them to effectively participate in the institutions that they belong to. This research aims to indirectly address this need. The development of natural resource accounts for an Aboriginal community and their traditional land base will not only provide information on measuring sustainability, but will hopefully also indirectly address the First Nation's ability to engage in the decisions about resource use and management.

Natural resource accounting (NRA) is a way of monitoring economic well-being that includes consideration of natural capital depreciation or appreciation. It involves both physical and monetary information, thus, providing a means of comparing different resource uses that exhibit some level of interdependence, like timber and wildlife for forest resources (Anielski and Wilson, 2001). It provides a description of resource use patterns in the area. At the same time, it offers a basis for analyzing if current resource extraction rates appear to be sustainable in the long run. In this context, resource accounting is a tool for assessing sustainability.

To provide a context for the sustainability assessment carried out in this thesis, a discussion of the existing institutional background governing resource use in the study area is presented. In the backdrop of resource use in the area is the complexity of existing

institutional arrangements that influence resource management. The discussion provides a glimpse of this complexity in relation to resource use in the area. The resource accounting exercise and the discussion of institutions attempts to help explain the concept of sustainability, both weak and strong sustainability, to address issues of scale, interdependence of use, and equity.

1.1. Rationale for the Study

Eighty percent of Canada's First Nations and Métis currently live within forested regions. First Nation reserves cover a total of three million hectares of forestland of which 1.4 million hectares (0.6 percent of Canada's productive forests) are suitable for sustainable logging practices (WRI, 2000). Aboriginal groups can be in a good position to fully benefit from these resources. In order to fully realize an effective strategy for sustainable forest management, it is important to assess traditional use and non-use values of Aboriginal people and collect and map the associated costs and benefits of resource use on the Aboriginal community.

Both use and non-use resource values contribute to Aboriginal people's economic, social, cultural, and spiritual lives, another reason why the incorporation of their values in resource accounts is important. However, these values are privately held by Aboriginal people and are sensitive in nature (Adamowicz, et al., 2002). Assessing these values, thus become a complex process. The uniqueness and diversity of their history, culture, and lifestyles, as well as the issues they face regarding property rights, make the process more complicated.

This research aims to address the following questions: 1) how should a resource account be developed in the context of a traditional area of Aboriginal peoples; 2) are

resources being used in a sustainable manner at the regional level; and 3) what economic welfare indicators are appropriate and applicable to the Aboriginal community. There is also an ongoing debate between the concepts of weak and strong sustainability, which mainly focuses on the substitutability between natural and constructed capital. This becomes a focus for this research as it relates to consistency of welfare comparisons and the use of renewable resources (i.e. forests) and non-renewable resources (i.e. minerals). Indirectly, this research addresses this issue by examining both renewable and non-renewable resource use in the area and examining how current extraction activities relate to sustainable resource use. Resource accounts are also extended to sub-surface natural resources, particularly oil and gas. This non-renewable component is pertinent in addressing issues of integrated resource management as related activities often conflict with those of forest industries and of Aboriginal people living in the area.

1.2. Objectives of the Study

The main objective of the study is to provide a detailed description of resource use patterns on the traditional area of the Heart Lake First Nation (HLFN). The specific objectives include:

1. To develop resource accounts for timber, wildlife resources and oil and gas;
2. To estimate current and future resource use trends and calculate economic rents;
3. To assess the level of sustainability of resource extraction in the Heart Lake First Nation traditional area; and
4. To assess the trends of the sub-accounts in the overall resource account and attempt to evaluate overall sustainability with consideration of values specific to the First Nation's community.

1.3. Outline of Thesis Discussion

This thesis is divided into eight main sections. **Section 2.0** discusses the theoretical background of this study, particularly the concept of sustainability. It also talks about the methodologies used. It mainly describes the different available approaches that one can apply in developing resource accounts and the existing related literature on these approaches. **Section 3.0** provides a description of the study area – Heart Lake First Nation (HLFN). The section includes a discussion on the geographical and demographical characteristics of the land and its people. The succeeding section, **Section 4.0** discusses the institutional background of the study area in relation to resource use and management. This includes a description of the relevant existing laws, acts and other regulations that govern resource use in the area. **Section 5.0** conveys the results of the study. The section is sub-divided into six sub-sections that present the results for both physical and monetary accounts for timber resources, gas production and wildlife. The results include estimates of past, current and future consumption. **Section 6.0** is a continuation of the results generated by this research and presents a discussion of how results from the resource accounts are related to the determination of the level of sustainability of resource use in the area. It also includes sub-sections on discussions between sustainability and institutions (6.3) and sustainability and aboriginal people (6.4). **Section 7.0** provides a summary and discusses the conclusion of the research and **Section 8.0** presents the limitations of the study and suggestions for further research.

2.0. Theoretical Background and Methodology

The most well-known definition of the concept of sustainability comes from the Brundtland Commission's report on "Our Common Future" that defines sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987). However, the challenge lies in addressing the issue of how to achieve sustainability in the absence of concrete indicators (Vincent, 2000; Lange, et al., 2003). "Sustainability" is operationalised in economics through the use of resource accounting (Lange, et al., 2003). Thus, resource accounting provides a basis for measuring progress towards sustainable development.

2.1. Definition and Measurement of Sustainability

The various definitions of sustainability have become a dominant issue in itself. Ayres et al., (1998) state that a popular interpretation of sustainability is that an economy is "... *weakly sustainable if the development is non-diminishing from generation to generation.*" Applying the economic growth theory, sustainability, thus, translates to intergenerational equity.

Compounding the issues on the definition, concept and implementation of sustainability are the similarities and differences between what are termed weak and strong sustainability. Van den Bergh and Hofkes (1999) define weak sustainability as a concept that allows for substitution between human-made and natural capital. It focuses on equal opportunities for present and future generations. The method of analysis involves the substitution of natural resources by human-made capital over time. Strong sustainability contends that both natural and human-made capital should be maintained

and therefore, the concept does not allow any forms of substitution of any kind (Van den Bergh and Hofkes, 1999). [2]

According to Pearce and Atkinson (1993; 1995) capital assets can be categorized into three; human-made capital (K_M), natural capital (K_N) and human capital (K_H). K_M refers to "reproducible" capital, such as roads, equipment, infrastructure, etc.; K_N are natural resources that include both renewable and non-renewable types; and K_H are stock of human knowledge and skills. By requiring that the net capital ($K = K_M + K_N + K_H$) remains constant, a basic condition for weak sustainability can be expressed as:

$$Z = \frac{S}{Y} - \frac{\delta_M K_M}{Y} - \frac{\delta_N K_N}{Y} \geq 0 \qquad \textbf{[1]}$$

where Z is a sustainability index, S is savings, Y is income, and δ is depreciation on capital. Thus, $\delta_M K_M$ and $\delta_N K_N$ refer to the depreciation in human-made and natural capital, respectively. Z must be greater than or equal to zero to assure weak sustainability. It is a zero-order rule for determining whether a country/community is on or off a path of sustainable development. This approach is complementary to environmentally adjusted national accounts, conventional economic aggregates "corrected" for environmental concerns. Pearce and Atkinson (1995) further developed the expression (**equation [1]**) for strong sustainability, where it requires that K_N at least remains constant and that K does not decrease.

[2] The concept of sustainability as argued by the neoclassical economists vis-à-vis ecological economists relate that human-made capital cannot be substitutes to natural capital as weak sustainability maintains, rather it is a complement (Daly, 2005). The determination of the relation between substitutes and complements is an interesting aspect of the analysis, especially concerning some of the values held by Aboriginal people on their land.

2.1.1. Measurement of Well-Being

In addressing the question of whether an area will be as well off in the future as it is in the present, the aggregate market value of consumption of goods and services found in national accounts, including the non-market values, can serve as an indicator of well-being (Kriström, 1996; Vincent, 2000).

According to Kriström (1996) there are two ways of measuring aggregate well-being, one is the value of changes in the constituents of well-being (freedom and utility) and the other is the value of the alterations in the commodity of determinants of well-being. More specifically, Kriström relates the use of shadow prices in measuring well-being, i.e.

> *"A key theorem in modern resource allocation theory is that, provided certain technical restrictions are met, for any conception of aggregate well-being, and for any set of technological, transaction, information, and ecological constraints, there exists a set of shadow prices of goods and services that can be used in the estimation of real national product (page 2)."*

He further stresses the importance of the inclusion of non-market benefits in resource accounts; however, this may be insufficient unless economic theory is available to provide consistency to the accounting system and the availability of appropriate methods to value the benefits.

2.1.2. Related Literature on Sustainability

A limited literature is available that measures sustainability at a smaller scale, i.e. not at the national level. The thesis research conducted by Pearson (2001) on "Macroeconomic Indicators of Sustainability for Alberta" applied environmentally adjusted income (EDP) and the Pearce-Atkinson measure (PAM) to assess weak sustainability for forest and energy resources in Alberta. The two approaches generated diverse results. Applying the EDP approach, she found that from 1971 to 1997 both sectors exhibit a level of sustainability where sufficient investments have been made to allow the economy to grow. However, using the PAM results she showed that investments were not enough to offset the value of disinvestments in natural capital, specifically for the energy sector. This finding included several caveats that included the level of accuracy of savings rate used for the study and the non-inclusion of human capital formation and technological change in the models.

In contrast to the use of resource accounts and sustainability indices, many studies apply different non-economic approaches in attempting to measure sustainability. One such study was done in North Eastern Alberta by Schneider et al., (2003). They applied a landscape cumulative effects simulator (ALCES) model, which tracks industrial footprints and ecological processes under different management scenarios. The results predicted that energy and forest activities lead to an increased density of human-origin edge of 8 km/km^2 from an original of 1.8 km/km^2, given a business as usual (BAU) scenario and an increase of 3.2 km/km^2 for a best practice (BP) scenario.[3] They suggest

[3] The business as usual (BAU) scenario refers to conventional management practices currently done by forest and energy companies in Alberta, while best practices (BP) scenarios are modified management schemes geared toward more sustainable practices. These BP scenarios may include changes in forest

that alternative management scenarios of "best practice" could lead to more sustainable extraction of resources and thus, economic benefits.

Further, Harris and Khare's (2002) paper "Sustainable Development Issues and Strategies for Alberta's Oil Industry," discussed whether current oil and gas activities in the province are sustainable and suggested strategies for its long-term survival. Generally they recommend that the Alberta Energy Utilities Board (AEUB) should encourage more public participation, and provide "built-in" incentives to conserve and develop the industry with the long-term public good in mind. They suggest that the diversification of resource portfolios, low cost strategies and focus on environmental protection will help industry achieve sustainability.

2.2. Natural Resource Accounting

The literature related to resource accounts has been increasing for the past two decades. Resource accounting has been applied to different types of natural resources such as the forests, minerals, and fisheries. In forestry alone, there have been more than 100 comprehensive valuation studies (Kriström , 1998). However, most of these accounts were done on large geographic scales, for example at national levels and often applying the United Nation's System of National Accounts (UN-SNA), while those that focus on smaller areas like resource-based communities are few. Rarer still are resource account studies that highlight regions where Aboriginal People live and their values.

2.2.1. Accounting Framework for Renewable Resources

Resource accounting in general, as described by Malër (1991) and Kriström (1996), is derived from the economic theory of resource allocation. The gross domestic

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harvesting schemes such as an increase in the variability of cutblock sizes and for the energy industry, the inclusion of the reclamation of disturbed areas.

product (GDP) has been a standard measure of national income in the early 1970s, but suffers several shortcomings as measures of aggregate economic welfare (Vincent, 1999). It only measures production and not welfare. Thus, the net domestic product (NDP), which is GDP minus depreciation of capital stocks, replaced the simple GDP. There is also the net investment that acts as an indicator of sustainability in exhaustible resources. Hartwick (1990) suggests that the net national product (NNP) is the best measure under standard national accounting procedures (Haener, 1998). It is the annual pay-off from the economy's capital stock. However, these accounts typically do not include depletion of natural resource stocks.

Depreciation of renewable resources can be calculated using the following formula (Hartwick, 1990).

$$D_r = (U_H / U_C - MC)(G - H) \qquad [2]$$

where,
U_H / U_C = marginal utility of harvest divided by the marginal utility of consumption of other goods
MC = marginal cost of harvesting
G = growth in stock
H = current flow of the resource

Vincent (1999) presented a framework for forest accounting where he discusses the adjustment of GDP for household consumption of non-market forest amenities and non-timber products but not for production externalities. Further, NDP should also be adjusted for the net accumulation of forest-related assets such as carbon stock and forestland use conversions to other uses. These approaches produce more internally consistent and theoretically sound adjustments for these indicators.

Indicators of welfare have sprung from earlier theories and approaches developed to understand the dynamics of how the environment is linked to the measurement or estimation of an economy's aggregate consumption. One such approach is measuring well-being through the net income measure. This is well exemplified in Dasgupta and Mäler's (1990) article on "The Environment and Emerging Development Issues" (pages 29-34). They presented a standard model exhibiting the relationship between consumption and the accumulation of environmental effects through the use of shadow prices and income accounts. This was modified by Haener (1998) for simplicity and to fit her study. Since Haener's approach on forest resource accounts has been adopted for this thesis research, the model presented in the succeeding discussion is similar to hers.

The variables used for this discussion include;

Y= aggregate output;
C= aggregate consumption;
L= labour effort
L_1= labour effort used to generate aggregate output;
L_2= labour effort used to enhance the growth of the timber stock;
L_3= labour effort used to harvest timber;
K_1= human-made capital;
K_2= environmental capital;
K_3= timber capital;
K_4= defensive capital;
X= timber harvest in the production of pulp and lumber;
S_1=timber harvested for the purpose of direct consumption through subsistence activities;
Z= flow of environmental goods and services;
P = pollution;
R= rate of pollution mitigation; and,
Q= expenditure on defensive capital

Forests, a renewable resource, have a natural regeneration rate, which can be increased by exerting some level of effort (L_2). Labour (L) is often measured using total

work hours. It is assumed that aggregate output (Y) is produced using both labour (L) and human-made capital (K_1), i.e.,

$$Y = F(K_1, L_1, X) \quad [3]$$

Specifically, Y refers to all output from pulp and lumber production and X, is timber input used to produce Y. It can be valued directly. Timber input also requires both labour and capital in order to be harvested, i.e.,

$$X = N(K_3, L_3) \quad [4]$$

However, other exogenous variables such as accessibility with road construction and the type of tree species being harvested also affect quantity of timber harvested.

Any related extracting activity will involve some level of externalities that will affect the surrounding environment, in particular pollution. However, Dasgupta and Mäler (1990) contend that the industry will, in some cases, invest in preventive measures and in mitigating technologies to minimize the impact of economic activities, i.e. in the form of defensive capital (K_4). Thus, the expression;

$$P = A(K_4, Y) \quad [5]$$

which relates that pollution level (P) is dependent on how much defensive capital (K_4) is expended and the overall total level of output. At the same time, society can also minimize the *"damages to the flow of environmental amenities by expending a portion of the final output, at rate R"* (Dasgupta and Mäler, 1990 p.30), i.e.

$$Z=J(R,P) \quad [6]$$

where the flow of environmental services (Z) is dependent on (R) and (P). In particular, the flow of environmental amenities in this case may involve forest goods and services

other than timber, such as carbon sequestration, recreational values and wildlife and bush harvests for Aboriginal people.

The relationships that these variables describe is that an economy is dynamic and that output Y can either be consumed or reinvested to increase stock K_1; it can also be invested in accumulating K_4; and used to mitigate damages to the flow of environmental amenities at rate R, i.e. in equation form:

$$\frac{dK_1}{dt} = F(K_1, L_1, X) - C - Q - R \qquad [7]$$

$$\frac{dK_2}{dt} = G(K_3) - A(K_4, F[K_1, L_1, X]) \qquad [8]$$

$$\frac{dK_3}{dt} = M(L_2) - X - S_1 \qquad [9]$$

$$\frac{dK_4}{dt} = Q \qquad [10]$$

$$X = N(K_3, L_3) \qquad [11]$$

$$Z = J\{R, A(K_4, F[K_1, L_1]\} \qquad [12]$$

Thus, well-being (W) is positively dependent on aggregate consumption (C), output (X), flow of environmental amenities (Z) and environmental capital (K_2); and negatively on total labour effort (L), i.e.;

$$W = W(C, S_1, Z, K_2, L_1+L_2+L_3) \qquad [13]$$

Having C, Q, R, X, L_1, L_2 and L_3 as instantaneous control variables to maximize the discounted sum of aggregate well-being, i.e. equation **[13]**, and using equations **[7]** to **[12]**, the current value Hamiltonian looks like:

$$V = W(C, S_1, Z, K_2, L_1+L_2+L_3)+ p[F(K_1, L_1, X) - C - Q - R] + q[G(K_3)-A(K_4, F(K_1,L_1,X))]+r[M(L_2,\bullet) - N(K_3, L_3) - S_1]+ sQ + v[J(R, A(K_4, F(K_1, L_1, X))-Z)] \quad \textbf{[14]}$$

Where *p, q, r* and *s* are the shadow prices for the four capital goods and *v* related as the imputed marginal value of the flow of environmental amenities.

Dasgupta and Mäler (1990) show that the information required to assess sustainability include a flow of goods and services (C, S_1, Z) and stocks (K_2) and the changes in all capital stocks (K_1 to K_4), the latter represents the appreciation (depreciation) of the capital stocks. The shadow values including that for labour must also be included in the estimation

2.2.1.a. Calculating Forest Resource Accounts

As discussed in the previous section, the main premise of resource accounts is to consider natural resources as an environmental asset. As for forest resources, uses include commercial forestry, fuelwood, and recreation, among others. Among the more relevant entries in the Aboriginal values for this research, however is the measurement of, timber values, trapping and hunting of animals, bush harvests, and other Aboriginal non-use and non-market values.

Specifically, forest resource accounting involves accounts for market and non-market goods, as well as use and non-use values. These can be measured either through a single-year or a time-series process. Market goods are defined as those goods and services that have assigned monetary values to them, i.e. prices, and are often traded

through formal markets. On the other hand, non-market goods are those that do not have any assigned prices, but nonetheless, have use and/or non-use values attached to them. The latter values are recognized as an important part of resource accounting, as to reflect the total economic value of resources.

There are two main studies that estimated resource accounts for Northern Alberta's forest resources. One is Haener's (1998) who developed an account that included both commercial and non-commercial uses of the forest. One of her main findings is that non-commercial uses comprised 40% of the total net income, stressing the importance of this component. She also found that fire risk played a major role in determining income flows over time as such should be an element in forest resource accounts.

Haener and Adamowicz (2000) extended the study for Northern Alberta that made use of secondary data from existing literature. The annual forest value for the entire region was estimated at $232 million. These included values from commercial forestry, fishing/trapping/hunting uses, recreational use, Aboriginal use and passive values.

Net income was distributed among the different sectors and the important aspect of this study is that it highlights the contribution of Aboriginal land uses at 7.6 percent. The values range from $8.35 to $26.8 million, which were based on previous studies that used replacement cost methods. The value included wood harvesting, hunting, fishing, trapping, food gathering, craft and traditional medicine.

2.2.1.b. Market Values for Forestry Resource Accounts

Market values for goods and services refer to those that can be valued by market prices. For forest resources, these often include commercial uses such as timber. Monetary accounts for timber resources can be developed directly from physical accounts by assigning appropriate values to timber stock levels and changes in these levels. The concept of economic rent is used in timber resource valuation (Baytas and Rezvani, 1993).[4] Economic rent provides an estimate of the net returns by determining whether current forest extraction activities provide net socio-economic benefits to society, and thus, become an indicator of social well-being (Anielski and Wilson, 2001). The simple formulation involves the following relationship:

$$R = P - TVC \qquad [15]$$

where (R) is the economic rent per cubic meter of timber harvested, which is the difference between price (P) and the total average variable cost (TVC) of production (Haener, 1998; Anielski and Wilson, 2001).

On the other hand, physical accounts involve both a flow and stock component for timber resources. The flow component consists of the physical amount of annual harvest to which monetary values are attached. The stock component estimates the annual physical change in the stock of standing timber (depreciation) and to which monetary values are also attached. The following relationship can be applied:

$$Closing\ Stock_{\ t} = Opening\ Stock_{\ t} - Removals_{\ t} + Additions_{\ t} \qquad [16]$$

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[4] Economic rent is *"the return to any input over the minimum amount required to retain it in its present use"* (Repetto et al 1989). Rent is the central concept for management and valuation of resources. It is not only part of the monetary aspects of it, but more importantly it becomes useful in measuring welfare changes. David Ricardo (1817) and Adam Smith (1776) originated the classical idea of rent. Ricardian rent simply describes that increasingly greater rent accrues to land of successively greater productivity with least productive land receiving no rent. Von Thunen (1966) expanded this concept to explain that rent is solely a function of location and not fertility or climate (*In* Callan and Thomas, 2004).

where t refers to time period.

The opening stock is an estimate of the timber volumes found on the study area. It is categorized as harvestable and productive, where timber supply for the pulp mill and local saw millers is sourced. Removals include estimates for annual allowable cuts (AACs) in the area and the volume of timber lost through forest fires. The additions variable of the resource account model describes the amount of timber that is added to the stock inventory. The addition comes as annual growth of timber stock in the area.

Anielski and Wilson (2001) conducted a forest resource account for the province of Alberta using a similar framework. The authors found a stable trend in the amount of closing stocks from 1961 to 1999 and with closing volume of 1.97 billion cubic meters of timber for 1999. However, the net change between the opening and closing stock through the 30-year period was less stable mainly due to the increasing rate of depletion.

Aside from timber, which is a marketed good, forest resources also provide goods and services that have no market prices assigned to them. The following sub-section discusses the concept, definition and methods for valuation of non-market value for forest resources.

2.2.1.c. Non-Market Values for Forest Resource Accounts

Non-market values for goods and services refer to those that do not have an observable monetary value attached to them. For forest resource accounts, these include both use values (e.g. recreation and hunting) and non-use values (e.g. existence values for certain species and cultural values). In general, use values can be estimated using revealed preference methods or stated preference methods; while non-use values can be estimated with stated preference methods. In this research, the focus is on use values, as

they are most tangible in the context of forest resource accounting at the community level. These use values may include hunting and trapping, fishing and other bush harvests.

In valuing activities for trapping and hunting, several methods can be applied. From the point of view of Aboriginal households, the amount of time spent hunting/tracking or the time spent on collecting animals may be used as an approximation for the value of the opportunity cost of time. The opportunity cost of time can be used to value the resource. Thus, the person conducting the valuation will need to know how the Aboriginal people use their time when they do not hunt or trap and their actual value for time itself. This technique can be difficult to implement since it depends on who the people are (place in the community) and the nature of their alternative income sources as well as their other sources of food (Francisco, 1992).

The earliest studies that have attempted to consider the use values that Aboriginal communities hold for forest resources can be traced back to the 1970s. In particular, Freeman (1976) conducted one of the first studies on Aboriginal communities, the "Inuit Land Use and Occupancy Project," where he documented Aboriginal land use over a wide area from an Aboriginal perspective. He employed a resource inventory in the study that was later developed by the Native Harvesting Research Committee (NHRC) in the early 1980s (*Cited in* Berkes, et al., 1995). Most of the early studies were conducted using mapping methods, where data are based on a recording and listing of resources that include plants and wildlife harvested and consumed by members of the community. This method has been an effective way to report use of resources, but has not been as useful in developing value estimates.

Despite a number of studies that acknowledge the role and importance of the traditional land-based subsistence economy in Aboriginal communities, valuation of subsistence use remains difficult and controversial. Wildlife and bush harvests have been evaluated from a number of perspectives, including their contribution to nutrition, socio-economic importance and cultural value (Berkes et al., 1994).

Since market prices are not readily available for some of these goods and services some researchers employ the contingent valuation method (CVM). This method involves asking an individual the value they have for a change in an environmental amenity or the maximum amount they would be willing to pay to have the change happen (Freeman, 2003). The Willingness-to-Pay and Willingness-To-Accept approaches can be used to estimate the value or consumer surplus of forest goods and services to users.

Travel Cost Methods (TCM) may also be used. The basic premise of TCM is that time and travel costs that people incur to visit a site is the price of access to that site (Freeman, 2003). This is an individual's willingness-to-pay to visit the site estimated using the number of trips that they make at different travel costs. This method is to some degree applicable to Aboriginal communities, when data on Aboriginal people's travel and means of transportation are examined along with their hunting and fishing activity. These are often measured through the amount of time consumed travelling, which is related to the notion of opportunity cost of time as discussed earlier (*See* page 19).[5]

Another popular method found in literature in attempts to measure non-market values for Aboriginal communities is the Replacement Cost Method (RCM). This is

[5] Instead of using the amount of time consumed, there are studies that convert estimates to calories burned, if a person walks (*See* Boxall and Beckley, 2002. pp. 130-131 for a case study) and for those who use motorized vehicles, costs may be approximated using the amount of gas consumed by the vehicle during the entire travel.

simply described as an approach that determines the gross value of the loss incurred from restricting an activity, say hunting, as the minimum cost to replace the good or service with its closest substitute (Dosman, et al., 2001). Two cases that use RCM are presented in the following discussions; one study was done in Alberta and the other in Ontario.

Research conducted by Bodden (1982) in "Subsistence Activities in Little Buffalo, Alberta", attempted to record subsistence harvest of a First Nation community as well as ascribe economic values for these harvests. The estimated total economic value was at $415,600/year for the whole community. This value included all animal harvests and wood collected for consumption and furs sold.

Another study was conducted by Berkes et al., (1994) on "Wildlife Harvesting and Sustainable Regional Economy in the Hudson and James Bay Lowland, Ontario" that aimed to report estimates of the numbers of animals of major species harvested over a one-year cycle, potential food weight represented by the catch and the imputed value of the harvest in relation to the overall economy of the region and to sustainable development. The methods used in the study included a survey conducted to all potential Cree hunters and valued all bush harvest using the RCM.[6] The study found that the total economic value of the traditional economy including meat, fuelwood, berries and fur was estimated at $9.4 million, while replacement value of the bush food harvest was $7.8 million at 1990 prices.

There are several critiques that have sprung up regarding the use of Replacement Cost Methods, among them is Adamowicz et al. (1994). The authors stated that replacement cost is only a valid measure of benefit in very specific circumstances and in

[6] Potential hunters refer to all males, 18 years old and above and female head of households. Hunters are often categorized as intensive, active, occasional, and non-hunters.

cases such as subsistence hunting, it may only measure a portion of the total value. Dosman et al. (2001) also suggested that RCM has a weak theoretical framework and that the monetary value derived from the method does not reflect any other value from the activity of hunting aside from the actual harvest.

Further, Haener et al. (2001) commented on the shortcomings of generating values through replacement cost methods in their study on using "Stated Preference Methods on Valuing Attributes of Subsistence Hunting by Aboriginal People in Northern Saskatchewan." The authors mentioned that replacement cost methods are unable to provide insight into the determinants of Aboriginal hunting behaviour and finding appropriate substitute values are difficult. Whilst citing these limitations, the authors of the study have incorporated the RCM with the stated preference approach. They have found that the common attributes used in Choice Experiment (CE) for non-Aboriginal hunters were different than those of Aboriginal peoples.[7]

Haener et al.'s study estimated a value of $300/capita/season that did not include the opportunity cost of time and $1,425/capita/season that included opportunity cost of time. The values refer to changes in hunters' welfare given a 25% decline in moose population. The values are coincidentally very close to those estimated by Berkes, et al.'s 1994 study. The use of stated preference methods allows a certain degree of flexibility with regards to taking into account impacts of environmental change to Aboriginal people. [8]

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[7] Choice experiments allow the collection of information on hypothetical choices that respondents would make given different environmental conditions.

[8] Dosman, et al., (2001) incorporated a combination of RCM, stated and revealed preference models. The study set out to develop methods on valuing Aboriginal resource values. The stated preference model explores how Aboriginal people state where they would hunt and how their behaviour may be altered given a change in their environment and the revealed preference method examines the actual number of hunting trips made, their frequency and their hunting location.

The methods discussed above are often time consuming and face considerable implementation issues. There is one method, though that can be applied to derive values for hunting/fishing or trapping activities that requires less time and the researcher is able to estimate values for different sites without necessarily conducting on-site surveys – this is known as the benefit transfer approach (BTA).

Benefit transfer is a process by which benefits estimated for a particular study site for which data exist are transferred to a policy site for which little or no data exist. According to Rosenberger and Loomis (2003), *"benefit transfer is a colloquial term adopted by economics and means the use of existing data or information in settings other than for what it was originally collected" (page 445).* The approach either involves the direct transfer of benefit estimates or the transfer of an entire benefit function. The latter approach occurs when an estimated benefit function for a study site is transferred to a policy site and its coefficients are used to compute the policy site benefits. This is a more rigorous approach, where the function relates peoples' preferences to ecosystem characteristics. When a benefit function is transferred, adjustments can be made for differences in these characteristics, thus allowing for more precision in transferring benefit estimates between contexts. The approach is used to account for the value of moose hunting in this study.

The estimates from the benefit transfer function are based on a behavioural linkage to environmental benefit valuation, which quantifies benefits based on observations of behaviour in either actual markets or survey responses about hypothetical markets for environmental goods (Callan and Thomas, 2004).

It is important to note that the benefit transfer approach, albeit straightforward and useful, is not without shortcomings.[9] Downing and Ozuna (1996) conducted an experiment to test the reliability of the benefit function transfer approach using CVMs, the results indicated that the approach overestimates benefits for the case of recreational saltwater fishing in Texas, which implied that the results from the approach may not be reliable.[10] This outcome was explained by non-linearity of the logit model used to estimate the benefit functions in the study; nevertheless estimates derived from using this approach should be interpreted with caution.

2.2.2. Accounting Framework for Non-Renewable Resources

Resource rent, the fundamental unit in resource accounting, arises from the natural scarcity of a resource. It is the difference between marginal revenue (MR) and marginal product cost (MPC) that can only come about as a result of the natural or policy induced scarcity of a resource (Callan and Thomas, 2004). Scarcity rent is measured using the unit price of *in situ* reserves and represents the present value of future benefit from an additional unit of resource stock that is incorporated in market price.

Hartwick and Hageman, (1993) present the following alternative, as applicable to non-renewable resources.

$$H_{rent} = (P - MC(Q)) \qquad [17]$$

[9] BTA is sometimes termed as a "quick-and-dirty" technique as it is afflicted with statistical and other problems (Kriström , 1996).

[10] Similar researches have been conducted that test the reliability of the approach using recreational studies. Kirchhoff et al. (1997) and Parsons and Kealy (1994) both rejected the reliability of the approach. A list of related studies is presented in the study by Poulos (2000).

where the classic Hotelling rent (H_{rent}) is the difference between the price of the resource (P) and the marginal cost (MC) of extracting quantity (Q). This is the rent on the marginal ton without discovery.[11]

A form of Hotelling rent that accounts for discoveries is:

$$(P - MC(Q))\text{-}MC(D) \qquad \textbf{[18]}$$

Thus, extended net economic depreciation or total Hotelling rent with discovery is:

$$H^{D}_{rent} = (P - MC(Q) - MC(D))(Q\text{-}D) \qquad \textbf{[19]}$$

where quantity extracted (Q) minus new discoveries (D) calculates net extraction.

Calculating depreciation (D^p) for mineral accounts is also dissimilar from forest accounting. Hartwick, (1990) developed the following formula to determine depreciation of non-renewable resources:

$$D^p = (P - MC)(D - Q) \qquad \textbf{[20]}$$

where
P = market price of resource
MC = marginal cost of extraction
D = new discoveries of the stock
Q = current extraction from stock

2.2.2.a. Calculation of Mineral Resource Accounts

The construction of physical accounts for mineral resources is relatively straightforward. It includes opening stocks, changes in stocks and closing stocks. Changes in stock include extraction, new discoveries and redefinition of assets (Lange, et al., 2003). Mineral accounts are categorized using two criteria, geological certainty and economic feasibility of extraction, as components of the McKelvey Box (Lange, et al.,

[11] Hotelling rent is associated with non-renewable resources that guides at what rate to extract the resource. It is rent that exists on the marginal ton of an exhaustible resource and is a measure of intertemporal scarcity of the resource (Hartwick and Hageman, 1993).

2003). In most countries, mineral accounts will only include proven reserves since there is difficulty in valuing probable reserves (Lange, et al., 2003).

Monetary accounts for non-renewable resources are the net present value of the stream of income they are expected to generate in the future or future resource rents. In particular, rent is calculated as revenue minus costs of extraction, including full capital costs, i.e. depreciation of fixed investment plus a normal return on fixed capital.

Smith (1992) developed physical and monetary accounts for the energy sector of Alberta from 1962 to 1988. Rent for natural gas was estimated for 1988 at $0.008/cubic meter and for oil at $11.15/cubic meter. However, the study's rent estimates for oil from 1962 to 1988 had extreme variations from a low of $0.19/cubic meter in 1967 to a high of $128.54/cubic meter in 1984. Physical stocks for natural gas had steadily been increasing during the period of study, however, gas rents had been moving the opposite direction. The author generally found that given the period of study, the provincial government had overspent oil and gas revenues, following Solow's rule of thumb.[12] Smith relates that spending was "*inconsistent with maintenance of the stock of wealth overtime*" (*page 406*). This conclusion is interpreted, however, with a caveat as the study made several assumptions regarding stock and rent calculations such as adjustment made only for depletion and not discovery and the choice of using the five percent rule of thumb.

Pearson (2001) found that Alberta's trend on energy stock has been increasing due to new discoveries. The Pearce-Atkinson measure (PAM) results however, generally show there is a depletion of energy resources in the province, not necessarily discoveries.

[12] Robert Solow contends that the "*...neat interpretation of allowable consumption as the interest on an initial patrimony or resource endowment seems quite appropriate. It is a reminder of the old-fashioned obligation to maintain capital intact*" (Smith, 1992: page 402). Specifically, Smith used a five percent rule on stocks that implies that real increases in rents of five percent a year are expected or that government spends five percent of the present value from future oil and gas rents (See Smith's Note 16).

Furthermore, Pearson relates that the "*resulting stream of energy rents has, to some extent, made it possible to ignore the problem of energy depletion, while energy prices have been high*" (*page 109*). This statement however, does not say that Alberta has failed to use energy rents for investments, with the Alberta Heritage Savings Fund (AHSF), the province has made investments on infrastructure, education and health (Smith, 1992; Pearson, 2001).

The literature review and methods presented in this section describe a variety of methods that can be used to estimate economic values and develop resource accounts. Knowledge of the approaches in estimating values for both renewable and non-renewable resources is important in measuring economic sustainability. As discussed in this section, sustainability is determined in a number of ways -- by the development of natural resource accounts and by the calculation and determination of the flow of resource rents. These approaches are applied in this research.

This section also highlights that there is a lack of existing studies that deal with sustainability at a small geographical scale, in particular in an aboriginal community. Although there has been research that estimates Aboriginal Peoples' economic values, this study attempts to include these values in the assessment of economic sustainability. The succeeding section describes the geographical focus of this research – the Heart Lake First Nation.

3.0. The Study Area

This thesis focuses on the Heart Lake First Nation (HLFN) in Alberta, and the traditional territory of the Heart Lake Aboriginal People. Heart Lake is derived from a Cree word meaning *"meeting place,"* which sounds like the English word for *"heart."* Historically, Heart Lake was situated at a gateway through which many Aboriginal people traveled, gathered and met (HLFN, 2002). HLFN is situated in the central eastern part of the province of Alberta, 45 kilometres Northeast of Lac La Biche. The total area of the reserve is 4,504.50 hectares with a total population of 256 (Statistic Canada, 2003). The population is generally young with only 10 people beyond 75 years of age. The employment rate is 35.7%, where most are engaged either in sales and services occupations or in trades, transport, and equipment operators (Statistic Canada, 2003). **Figure 1** shows a map of where Heart Lake reserve is found in Alberta. The community reserve is on the west side of Cold Lake. The traditional area encompasses most of the east central Alberta and adjacent areas of west central part of Saskatchewan (Stevenson, 2002).[13]

The Heart Lake community is highly dependent on their land. On September 8, 1876, treaty rights for the Heart Lake First Nation were established under Treaty Number 6. It assured the First Nation that the reserve was set aside for their use. Their main economic activities include hunting, trapping and fishing. There are also bush-gathering activities such as collecting firewood (most commonly spruce, poplar and birch), medicinal plants and berries.

[13] Traditional area refers historically to the land that the First Nation either occupied for settlement or had used certain resources; say for hunting and fishing, while homeland area was designated after the signing of Treaty 6 (Stevenson, 2002). Treaty 6 is further discussed in Section 4.0.

Three other major stakeholders are active on the traditional area. These include, Alberta-Pacific Forest Industries, Inc. (Al-Pac) [14] who holds four forest management units (FMUs) on the traditional land, Canadian Natural Resources Limited (CNRL), an oil and gas company, and the Department of National Defence (DND) that manages the Cold Lake Air Weapons Range (Bombing Range).[15] The interactions between these stakeholders influence how resources are used and managed in the area. **Section 4.0** discusses these interactions in detail.

[14] It is interesting to note that Al-Pac participated in the establishment of the Sustainable Forest Management Network Centres of Excellence based at the University of Alberta.
[15] The Cold Lake Air Weapons Range is also sometimes known as the Primrose Lake Air Weapons Range.

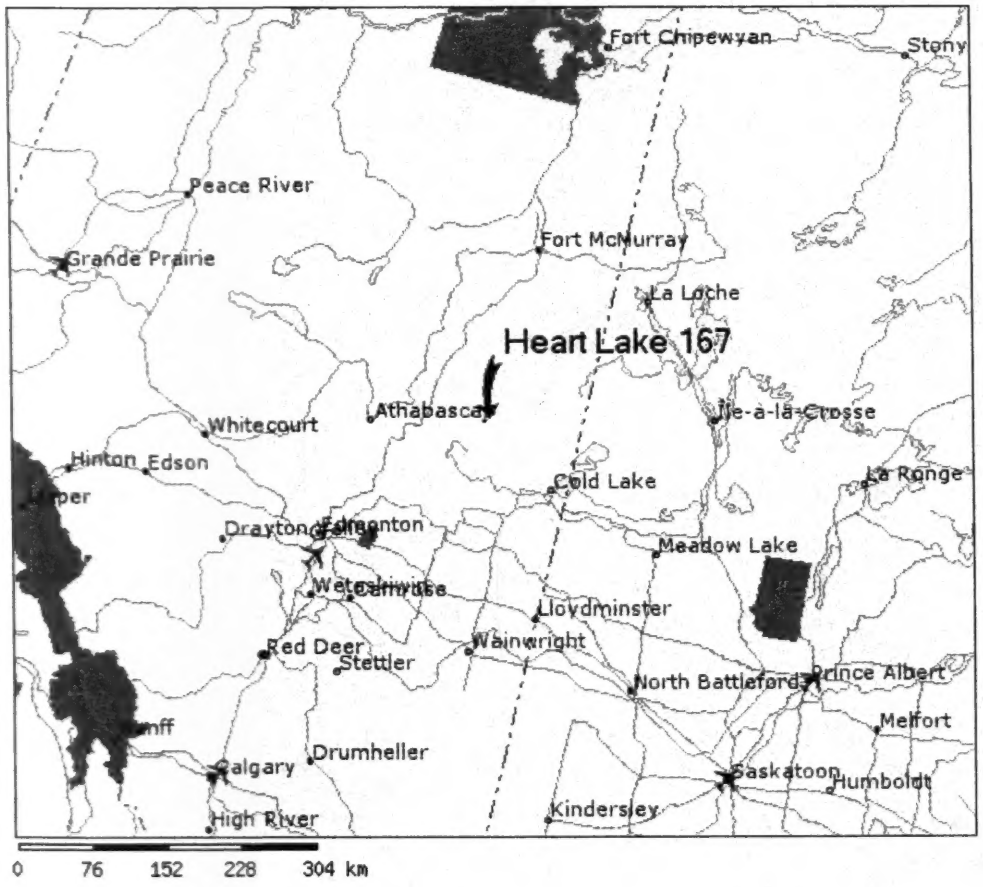

Figure 1. Map of Heart Lake First Nation Reserve [16]

[16] Source: Natural Resource Canada. 2005. http://atlas.gc.ca

4.0. Property Rights and Resource Use

The link between natural resource management and property rights has often been discussed in the literature. Environmental policy often involves analysis of the rights and duties, and benefit streams that represent property to various interests (Bromley 1991; Javier, 2003). The general presumption is that institutions have great impact on how well people attain their economic and other objectives.[17] Individuals normally prefer institutions that enhance their freedom of choice and economic well-being (Kasper and Streit, 1998).

Several groups present in the traditional area benefit from the available natural resources.[18] This section identifies the type of property rights that stakeholders have over the land and explores how existing policies governing resource use influence the interactions between the different stakeholders. It provides the institutional backdrop for the study site, which plays an important role in describing how the resources are currently managed and how it can encourage or restrict the possibilities for sustainable resource management.

Specifically, the discussion presents the current context at Heart Lake in which several types of resources are found on the area and as such several institutions can also be identified that govern the use of these different resources. These institutions may overlap leading to resource use conflicts.

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[17] Institutions sometimes refer to rules, policies and rights instead of an organization or to a group of organized individuals.

[18] Although, the public is a stakeholder, due to the complexity of their values on nature and wildlife and recreation, they are specifically excluded from the discussion; however, the government through its policies is assumed to represent the interests of the general public.

4.1. Legal Institutions Present at Heart Lake

The two major laws governing rights of Aboriginal people are the Indian Act and Treaty rights. In 1868, the Act for the Gradual Civilization and Enfranchisement of Indians formed the foundation for the Indian Act of Canada, a law that limits reserve land to bands for their *"use and benefit in common"* (Owens, 2002). Section 10 of the Act describes a political framework,

> *"... a band may assume control of its own membership if it establishes membership rules for itself in writing in accordance with this section and if, after the band has given appropriate notice of its intention to assume control of its own membership, a majority of the electors of the band gives its consent to the band's control of its own membership."*

The Act does not give protection to individual rights, such as rights to property (Ross and Smith, 2002; Owens, 2002). It is only by virtue of membership in a band that an individual be entitled to a property held in common by the band, which is a form of community property right. Almost all of the transactions made by a First Nation are subject to the approval of the Minister of Department Indian Affairs and Northern Development (DIAND), such as bequeathing a property to another individual and selling land (Refer to Section 45).[19]

The government of Canada negotiated a set of 11 treaties for Western Canada for the reservation of land to individual bands (Owen, 2002). In particular, treaty rights for the Heart Lake First Nation were established under Treaty 6, signed on September 8, 1876. Treaty 6 assured the First Nation that reserves are set aside for their own use and agricultural activities. They were guaranteed continued hunting, trapping and fishing

[19] "Minister" will refer to the Minister of DIAND.

rights over the ceded traditional territory. There is a provision in the treaty that conveys the government's ultimate power to control land use, i.e., in paragraph 16,

> *"...subject to regulations as may from time to time be made by government of the country acting under authority of Her Majesty and saving and accepting such tracts as may be required or may take up from time to time for settlement, mining, lumbering, trading or other purpose."*

The Canadian forest sector has a unique property rights system. Since the federal or provincial government owns most of the forestlands, resource management lies partly within the domain of the government. Resource management in the country involves legislation, regulations, tenure agreements, license permits and government policies and acts that define the rights and responsibilities of individuals to grow and harvest the resources on the land (Ross and Smith, 2002).

In Alberta, the Forestry Act enables the Minister of Sustainable Resource Development (SRD) to dispose Crown timber through a Forest Management Agreement (FMA) (Ross, 2002). The agreement allows a holder to *"enter a forest land for the purpose of establishing, growing, and harvesting timber in a manner designed to provide a perpetual sustained yield"* (Forestry Act; Ross, 2002). In the Heart Lake region, the FMA belongs to Alberta Pacific Forest Industries, Inc. (Al-Pac), that started operation in 1994.[20] Interestingly, the FMA contains provisions that will enable the government to facilitate oil and gas exploration and development on FMA lands (Ross, 2002).

In the extraction of mineral resources, the Mines and Mineral Act defines the exploration of oil and gas as *"...any operations on or over land or water to determine geologic conditions underlying the surface of land or water"* including preparatory

[20] At the writing of this chapter, the Chipewyan and Heart Lake First Nations will be receiving C$300,000 from federal funding to assist them in a joint partnership to harvest 180,000 cubic meters of logs annually for Al-Pac, Inc..

activities or otherwise connected to these operations. Exploration is conducted with a license and an approved exploration program. Exploration equipment must have a permit as well. Aerial and ground surveys need no exploration approval as long as it does not disturb land or vegetation cover. The Act contains provisions and guidelines on field operations and regulations on production. After exploration, companies must acquire surface rights to engage in mineral development. The Minister of SRD has the powers to dispose surface rights on public lands and the Act does not provide for any rules or objectives to be pursued when allocating lands (Ross, 2002). Canadian Natural Resources Limited (CNRL), a Calgary based company, is the oil and gas company that has acquired both surface and sub-surface rights in Heart Lake traditional area.[21]

Another stakeholder in the HLFN traditional area is the Department of National Defence (DND). In 1954 the federal government established the Bombing Range on a 11,629 hectare parcel of land in east central Alberta (5,252 hectares) and west central Saskatchewan (6,376 hectares). The territory included the best hunting, trapping and fishing grounds available to First Nations in the area (HLFN, 2002). When the Bombing Range was established, both Cree and Dene people of Heart Lake were required to register trap lines in the area, however, it has been claimed that only a handful of people were able to afford this and those who gave up their trap lines were not properly compensated (HLFN, 2002). In particular "*... historical records reviewed by the Band do not indicate that adequate compensation was made available*" (HLFN, 2002, page 45). There was no economic development plan that assisted the people to cope with the loss of their traditional livelihood. People became dispersed; some joined other First Nations,

[21] Aside from the Mines and Minerals Act, the Canada Petroleum Resources Act serves as a policy that regulates interest in oil and gas production at ground operation levels.

while some moved to Edmonton. By 1972 the community was afflicted by underemployment and welfare dependency, which has persisted for the past two decades (HLFN, 2002).

4.2. Multiple and Conflicting Resource Use

Laws and regulations governing resource use typically provide protection of an individual's rights and interests on the land; however, resources are often used in conflict with another individual's interests, a situation found on forestlands. Forestlands provide multiple uses for stakeholders, exemplified in this study's research area. Albeit, laws and acts intend to provide rules to minimize resource use conflict; for example, the Canada Petroleum Resources Act Section 3 relates *"...nothing in this Act shall be construed so as to abrogate or derogate from any existing Aboriginal or treaty rights of the Aboriginal peoples of Canada under Section 35 of the Constitution Act, 1982"* -- conflict still arises that attenuates one's property rights.[22]

The forest vis-à-vis energy resource use on the study area can sometimes have conflicting management schemes and uses for the area. If the original land that is part of an FMA can be given out to energy companies, then, this conflicts with forest company's rights.

Laws governing oil and gas industries appear to be more comprehensive and provide greater flexibility, in terms of transferability than those governing forest resources. With the differences in the privileges and degree of flexibility provided by the institutions to the different stakeholders, there seems to be a level of inequity. This perhaps contributes to the increased occurrences of resource use conflicts. Resource-use

[22] If and when a conflict arises with the provisions provided by the different laws and acts, the Doctrine of Paramountcy prevails, i.e. federal laws and acts prevail (Funston and Meehan, 1998).

conflicts may be decreased if laws are clear and more transparent and provide a detailed guideline of how resource extraction activities are conducted; however, altering existing laws and regulations takes a long time to accomplish.

An alternative way to reduce, if not eliminate resource-use conflict and also cumulative impact is perhaps thru an effective Integrated Resource Management (IRM) approach. The Alberta government has identified IRM as a component of its commitment to sustainable development via its Integrated Landscape Management (ILM) program with the Alberta Chamber of Resources (ACR) (Kennett, 2002). The aspects of IRM and how it can support sustainable resource use in the study area is discussed further in the latter portion of this thesis.

The discussion in this section shows that various laws and regulations govern different stakeholders on the Heart Lake traditional land, each institution seemingly protecting the interests of the sectors for which the laws were formulated. The knowledge of the current situation should help in policy analysis and in understanding resource use patterns.

5.0. Natural Resource Account Results and Discussion

This section discusses the natural resource accounts developed for timber harvesting and wildlife consumption activities in the traditional area of the Heart Lake First Nation (HLFN). It estimates past, current and future resource use trends as well as calculates economic rent for timber resources. Demand for wildlife, specifically for moose (*Alces alces)* is also estimated using the benefit transfer approach. In addition to timber and wildlife resources, oil and gas extraction activities are also present in the area and the resource accounts developed for this resource are discussed in the latter part of this section.

5.1. Timber Physical Account

The results for physical accounts are divided into three main parts. The first part (**Section 5.1.1.**) presents timber accounts that are projected from 2000 to 2014. The second part (**Section 5.1.2.**) discusses two main results; one is a timber account based on a harvest trend that used actual figures for deciduous harvests for the period of 1996 to 2002; and the other is a timber account based on a harvest trend that used backward forecasted harvest figures for the 1996-2002 period. Values used for backward forecasting were based on the projected timber accounts. The last part (**Section 5.1.3.**) discusses the implications of not including insect infestation in the development of physical accounts.

5.1.1. Projected Timber Resource Accounts (2000-2014)

Alberta-Pacific Forest Industries, Inc. (Al-Pac) holds the forest management agreement (FMA) on Heart Lake First Nation's traditional area and is responsible for the extraction of forest resources and its management. The company has a total of twenty

(20) forest management units (FMUs), four (4) of which are in the Heart Lake traditional area.[23] The four FMUs include L4, L5, and L6, all from Zone A and L1 from Zone C. **Figure 2** illustrates Al-Pac's FMUs.

Data for timber volume stocks, annual allowable cuts (AAC) and projected annual wood requirements and supplies were taken from Al-Pac's detailed forest management plan (2000). These data were used to calculate different aspects of forest accounting that included a 15-year projection for physical timber accounts, projected annual wood requirements and supplies and the total value of pulp mill and saw mill production in the four FMU's.

[23] An FMU is a defined area of forest land located in the Green Area of the province and designated by the Department of Environment to be managed for sustainable timber yield (Al-Pac, 2000). FMA is a renewable agreement between a private company and the Alberta government, which grants that company the rights and obligations to manage grow and harvest timber in a specified area on a sustained yield basis.

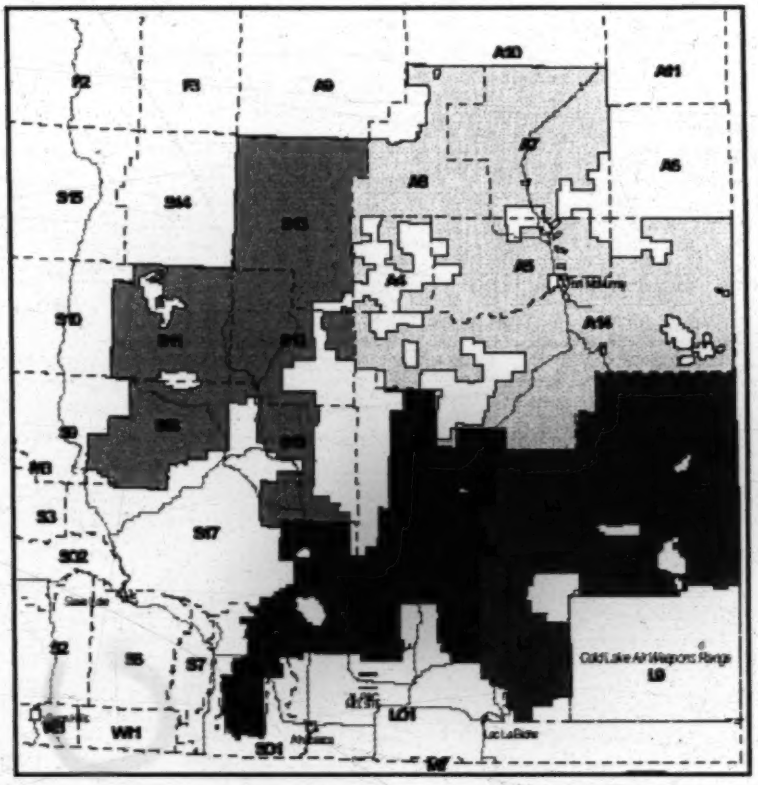

Figure 2. Al-Pac's Forest Management Area [24]

The 15- year timber stock physical account for Heart Lake First Nation traditional area was conducted using the equation presented earlier (**equation [16]**):

$$Closing\ Stock_t = Opening\ Stock_t - Removals_t + Additions_t$$

The opening stock for period *t* refers to the amount of closing stock in period *t-1*. Removals include estimates for Al-Pac's annual allowable cuts and volume of timber lost through forest fires. The AAC includes Al-Pac's annual harvests of both deciduous and coniferous species, incidental conifers, and annual harvests by quota and coniferous

[24] Source: Al-Pac, Inc.'s Detailed Forest Management Plan (1999)

timber permit (CTP) holders on the FMA. The AAC estimates are based on a 20-year schedule, from 1996 to 2016 that helps ensure harvests are sustainable (Al-Pac, 2000).

Fire incidence rates were simulated (Monte Carlo simulations) using the range presented by Armstrong (1999). Volume of timber destroyed by fire is also included in the removal variable of the model, and the fire incidence rate used ranges from a low of 0.006296% (Armstrong, 1998) to a mean of 1.10% and a high of 2% annually (Armstrong, 1999).[25] It is assumed that timber is consumed entirely by fire and none is left for salvaging, thus perhaps overestimating the value of loss from fire.[26]

The additions variable of the resource account model describes the amount of timber that is added to the stock inventory. The addition is as annual growth of timber. The growth rates used in the accounts are based on Anielski and Wilson's (2001) estimates for Alberta's annual growth ranging from 1.315 m^3/ha/year to 1.723 m^3/ha/year and averaging, 1.438 m^3/ha/year. These translate to 1.17% to 1.18% annual growth rates. This range is not far from Haener's (1998) use of 1.08% for her 1996 physical stock accounts.

The timber physical account shows a trend that given no major disturbance in the next 15 years, the volume of timber stock is increasing; suggesting short-term sustainability. This result is illustrated graphically in **Figure 3**. The physical timber account generally shows that the net change in physical stock increases steadily over the next 15 years despite the removals, exhibiting short-term sustainability of harvesting

[25] Estimates for mean annual burn rates fit a log normal distribution and in general, the natural disturbance regime in the area is characterized by large annual variations (Armstrong, 1998).
[26] On the other hand, the non-inclusion of timber destroyed by insects and disease may add to underestimating the total value of removals. This is discussed further in the succeeding section.

operations. **Appendix Table 1** shows the calculations for a 15-year timber stock for the years 2000 to 2014, which illustrates how the values were calculated.

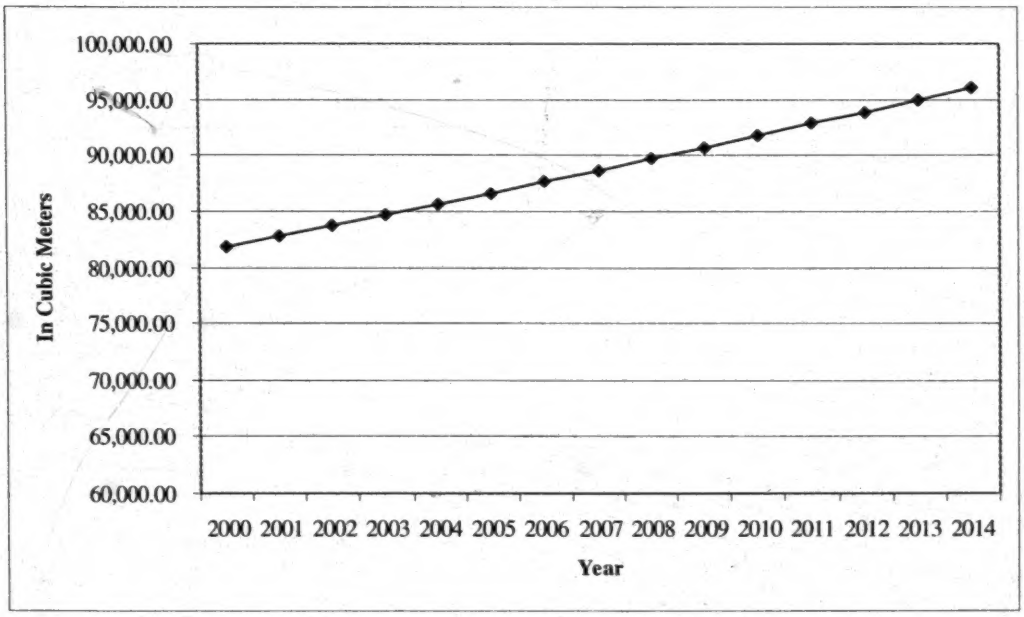

Figure 3. Total Net Change for a Projected 15-year Physical Timber Stock

5.1.2. Timber Accounts based on Predicted and Actual Extraction Trends (1996-2002)

This study was able to obtain data on the actual amount harvested (for deciduous species) during the period of 1996-2002 as reported by Al-Pac and use this data to show how the harvest trend looked in the past. **Appendix Table 2** shows that by applying the actual amount harvest, there has been an uneven harvest of timber stock over time in the area, i.e. net physical change is negative from 1997 to 2001. This is illustrated in **Figure 4.** This result can be explained by the fact that the assigned amount of annual allowable

cut to a company is distributed in the area upon the discretion of the company. Thus, even if Al-Pac's management plan states that a certain amount is to be harvested from a particular FMU, they can choose to reallocate some amount of harvest to other FMUs as long as they harvest within the total AAC that was granted to their FMA. [27] However, despite the negative trend from 1996-2001, available opening stock in the traditional area was able to recover from the slump in 2001 given the additions from growth and appears to be sustainable in terms of timber volume. On the other hand, using the same timber stock accounts projected in the previous section (shown in **Figure 3**) the study predicted past harvest trends by applying "backward forecasting" instead of using the actual deciduous harvest data (*Also in* **Figure 4**). **Appendix Table 3** shows that the growing physical stock is increasing, thus net changes have been positive for the area.

[27] Cut control is given at an FMA level and is distributed/harvested in 5-year increments. In the past two years, the primary flow of fibre has come from salvage, mainly from the House River burn and from the energy sector, particularly Steam Assisted Gravity Drainage (SAGD) developments and Oil Sands projects. Thus, flows will not correspond to FMUs per se. Al-Pac recently submitted a new Forest Management Plan, which is expected to be approved in the last quarter of 2005, cut control will then be set at the FMU level. (Information derived from personal correspondence with Dave Cheyne, Management Forester, Al-Pac, Inc.).

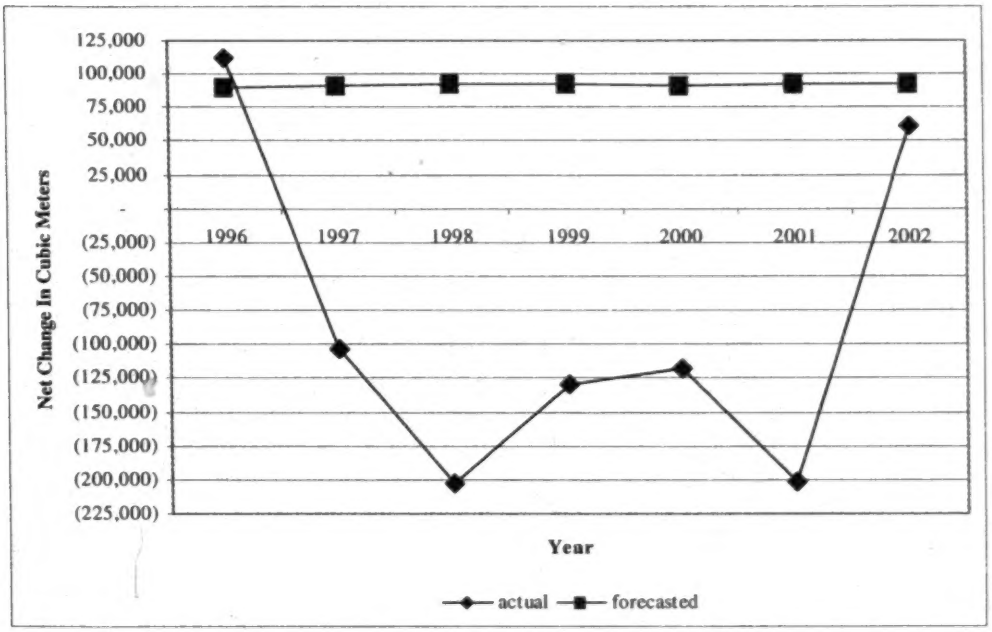

Figure 4. Timber Stock Trend using Values for Predicted and Actual Harvests

5.1.3. Non-inclusion of Insect Infestation

Incidence of insects and diseases were not included in the physical account of this study due to difficulties associated with estimating the actual degree of damage that insects and disease have on standing timber. Although Anielski and Wilson (2001) assumed mortality in their development of Alberta's timber volume account and included total number of hectares infested by insect and disease for their forest area (productive) account, available data are aggregated for the entire province. It was difficult to obtain specific estimates for the Heart Lake study area. Insect infestations often happen repeatedly over the same area of forestland and may neither result in death nor a loss in sustained yield (Anielski and Wilson, 2001). This contributes to the complexity of

interpreting infestation figures, as infested areas do not always translate to a loss in land base and/or in timber harvest. Anielski and Wilson (2001) noted that since salvaging operations are dependent on the type of pest, pest severity and management objectives for the area infested and that growth and yield estimates already account for past insect and disease activity, the inclusion of this variable may lead to double counting.

5.2. Timber Monetary Account

This sub-section presents results for timber monetary accounts and is divided into two parts. The first describes monetary values for annual timber flows and annual rent calculations for both pulp and lumber production. The second part shows results of forecasted monetary values for pulp and lumber from 1996 to 2010.

5.2.1. Monetary Accounts for Timber Flow Value

Monetary values are also important in timber resource accounting, as physical accounts are not sufficient to assess the level of well-being and sustainability for the study area. Average variable cost figures are not available for the year 2000. Instead, the study used the values in the work by Reinhardt (1994) as applied in Haener (1998). The total variable costs and average pulp prices were converted to year 2000-dollar values.[28] **Table 1** shows economic rent estimates for pulp production in the HLFN traditional area for 2000. Economic rent for Hardwood Bleached Kraft pulp (HBKP) ranges from a low $89.16 to a high $110.22 and for Softwood Bleached Kraft pulp (SBKP) ranges from a low $60.23 to a high $77.84. The difference in range between the two types of pulp is brought about by the higher pulp price for HBKP.

[28] Information on marginal costs (MC) is rarely available, thus often, studies use average costs (AC) as a substitute, however, since MC>AC, rent may sometimes be overestimated (Pearse and Atkinson, 1995).

Table 1. Annual Economic Rent Estimates for Pulp Production in the HLFN Traditional Area by Al-Pac (In 2000$)

Pulp Type	Average Pulp Price ($/ADMT)	Total AVC ($/ADMT)	Economic Rent ($/ADMT)	Economic Rent ($/$m^3$ wood input)
HBKP				
Low	972.97	536.09	436.88	89.16
High	972.97	432.92	540.05	110.22
SBKP				
Low	889.04	536.09	352.95	60.23
High	889.04	432.92	456.12	77.84

Note: ADMT refers to air-dried metric tons. Economic rent for $/$m^3$ wood input is a result of conversion factors for pulp production to wood input of 4.9 m^3/ADMT for HBKP and 5.86 m^3/ADMT for SBKP.

Table 2 shows the projected annual wood requirements and supplies from the HLFN's traditional area. The estimates presented here are difficult to derive. Estimates for the coniferous portion of the AAC are received in the form of chips from sawmills. The AAC for incidental conifer is offered to conifer saw log operators and only the portion of the volume expected back in chips, which is 40%, is included in the table with the purchased chips (Al-Pac, 2000). The wood requirements and supplies are based on Al-Pac's harvests from the traditional land.

Applying the derived estimates for volume harvested and the economic rent estimates presented in the preceding table, the results for the estimated value of pulp and lumber production are shown in **Table 3.**

Table 2. Projected Annual Wood Requirements and Supplies from HLFN's Traditional Area (2000)

	Deciduous m^3/year	Percentage Contribution	Coniferous m^3/year	Percentage Contribution	Total m^3/year
Total Wood Supply from entire FMA					
FMA AAC	2,190,474				
Purchased Chips	-		425,000		
Wood Supply from Traditional Area					
AAC from Relevant FMUs	495,713	23	***		495,713
Purchased Chips (from AAC)	-	-	144,000		144,000
Purchased Chips (from Incidental Conifers)			22,948		22,948
Total Purchased Chips			166,948	39	166,948
Total					**829,609**

Note: *** - The conifer AAC of 144,000 cubic meters is delivered to the sawmill operators and purchased back as chips.

Table 3. Flow Value of Pulp and Lumber Production from Traditional Area (In 2000$)

	Low Estimate			High Estimate		
	Rent ($/$m^3$)	Harvest (m^3)	Value (2000$)	Rent ($/$m^3$)	Harvest (m^3)	Value (2000$)
Pulp						
HBKP	89.16	495,713	44,197,131.44	110.22	495,713	54,634,868.54
SBKP	60.23	144,000	8,673,092.41	77.84	144,000	11,208,437.04
Sub-Total			52,870,223.86			65,843,305.58
Lumber*	53.62	35,872	1,923,501.70	53.62	35,872	1,923,501.70
Total			**54,793,725.56**			**67,766,807.29**

Note: *Rent calculation for lumber was derived from Haener's (1998) earlier estimate and harvest value is based on figures of conifer AACs for Quota Holders on the traditional land, assuming their harvests do not go straight to pulp mills.

Economic rent estimates are shadow prices and are therefore used to value the flow and stock component of the timber account (Haener, 1998). The flow component consists of the annual allowable cut for Al-Pac and the quota holders for purposes of pulp and lumber production, while the stock component refers to the change in the value of

merchantable timber over the period. The table shows the total value for pulp and lumber ranges from a low of $54,793,725 to a high of $67,766,807. The range is brought about by the difference in the range of total average variable costs and the sharp increase of price indices in the years 1996 and 2000. **Appendices A** and **B** show the graphs of Price Indices used in the study.

5.2.2. Forecasting Monetary Accounts (1996-2010)

As this study examines sustainability in resource use, 15-year economic rent estimates for both HBKP and SBKP have also been forecasted. **Figures 5 and 6** show the trend for economic rents up to the year 2010, which are fairly stable. Prices were projected using a 5-year moving average technique. In the year 2000, it can be seen that there has been a sharp increase in economic rents for both HBKP and SBKP; this is brought about by an unprecedented hike in pulp prices for that year. The price hike had in part generated the record high Canadian forest products exports of $47.4 billion (http://www.nrcan-rncan.gc.ca). Aside from that year, the outlook for the economic rent from timber resources from the study area is relatively stable.

Total flow value for lumber and pulp production also shows a stable trend until the year 2010. Again, for the year 2000, pulp prices were high, however, flow values for lumber are more stable and in contrast, for the same year lumber prices decreased and did not follow the trend of pulp prices. This was brought about by softwood lumber prices that have declined steadily during 2000 and as a result the value of exports declined by $1.1 billion (http://www.nrcan-rncan.gc.ca). **Figure 7** shows the results for this trend.

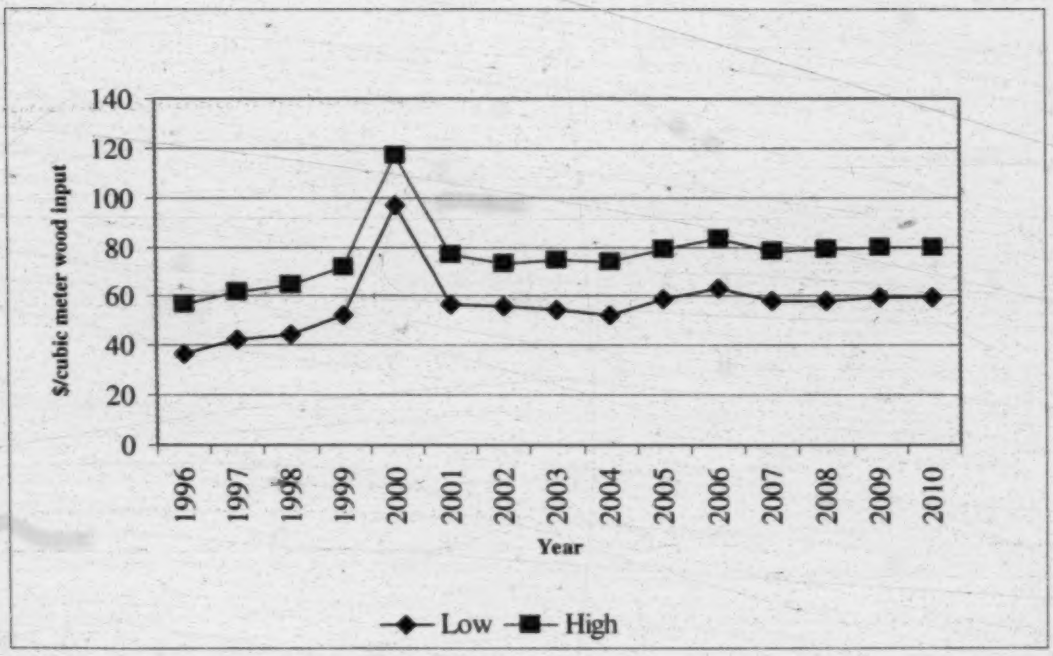

Figure 5. Low and High Economic Rent Estimates for HBKP

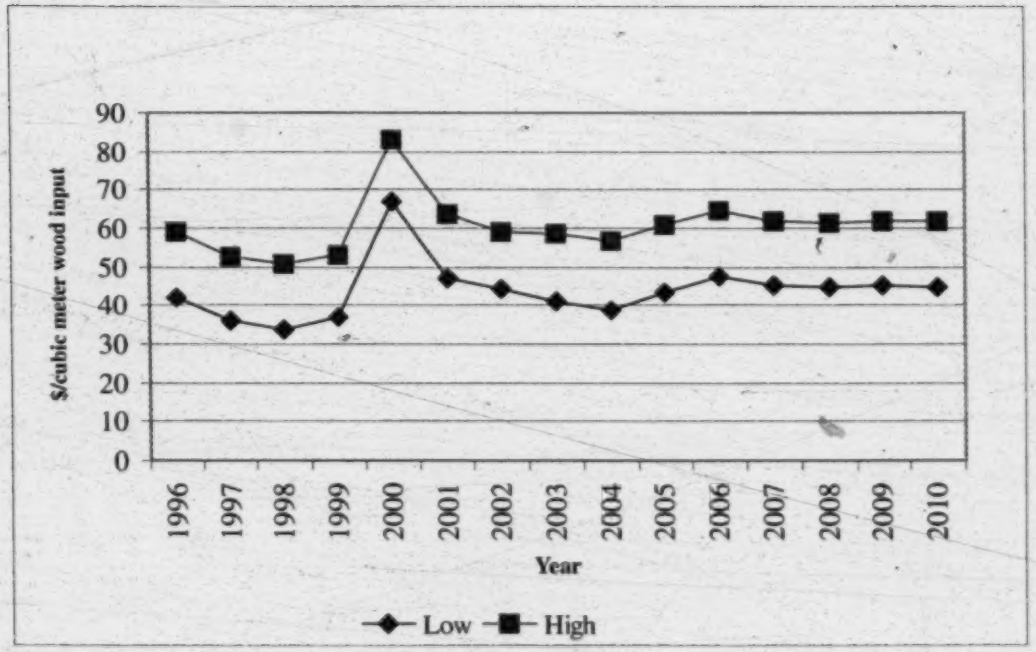

Figure 6. Low and High Economic Rent Estimates for SBKP

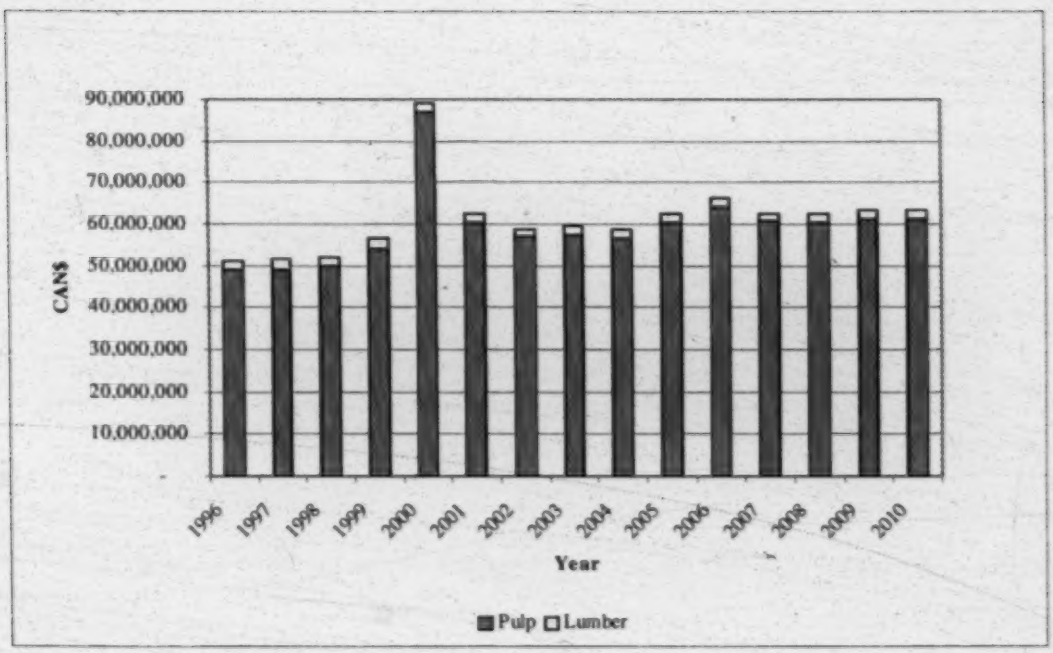

Figure 7. Flow Value for Lumber and Pulp Production (High Estimates)

5.3. Wildlife Accounting through Aboriginal Moose Hunting[29]

A component of forest resource accounting includes wildlife resources. The inclusion of the non-market use value for Aboriginal moose hunting in resource accounts is important. Hunting represents the lifestyle and culture of the community. Furthermore, the treaties suggested that benefits from hunting would be guaranteed. The benefit

[29] Data for variables related to moose abundance model and later on those that were used for the hunting models were generated from the Alberta Vegetation Inventory (AVI). The AVI is a photo-based digital inventory that identifies the type, extent and conditions of vegetation, and the changes occurring. AVI occurs on land managed by the Crown, land managed under a Forest Management Agreement (FMA) and others including Metis Settlements, First Nations and Federal Parks. (http://www3.gov.ab.ca/srd/land/g_data-catalogue_avi.html)

transfer approach (BTA) is used to account for the value of moose hunting in the study area. For this study, the estimated functions applied by Adamowicz, et al. (2004) were used. They employed a two-step process that first estimated the probability that a region had high quality moose habitat and then they estimated the probability that a region is visited as a function of habitat and hunter characteristics. They applied a logit model to estimate the probability that an area had exceptional moose habitat. The moose abundance model they used is based on:

> *Probability of area having high moose populations = f (density of rivers, percentage of area with new cut, percentage of area with water, area of muskeg and crown closure, and presence of salt licks)* [30] **[21]**

The parameter estimates derived from this model were used to determine the probability of an area having exceptional moose habitat for the Heart Lake community.

In particular, wildlife resource accounting analysis was concentrated on the homeland area of the Heart Lake community. It is important to explain here that the unit of analysis was a township instead of an operating area in the FMA as used in the Adamowicz et al., (2004). The Alberta township system was divided into four quadrants and each having 2,331 hectares of land. Each quadrant has 9 sections, as the township system is divided into 36. The homeland area of Heart Lake First Nation involved 24 townships, thus a total of 96 areas can be used for the study's analysis. However, since 13 areas are covered with only water, these were deleted from the analysis, leaving only 83

[30] Based on Adamowicz et al. (2004), if the probability of an area having a high moose population is at 0.05, it would suggest signs of less than 1 moose /day; at 0.375 - signs of 1-2 moose/day; 0.75 signs of 3 moose/day and 1.0 signs of more than 4 moose/day.

areas. **Figure 8** exhibits how the township level was subdivided as this study's unit of analysis.[31]

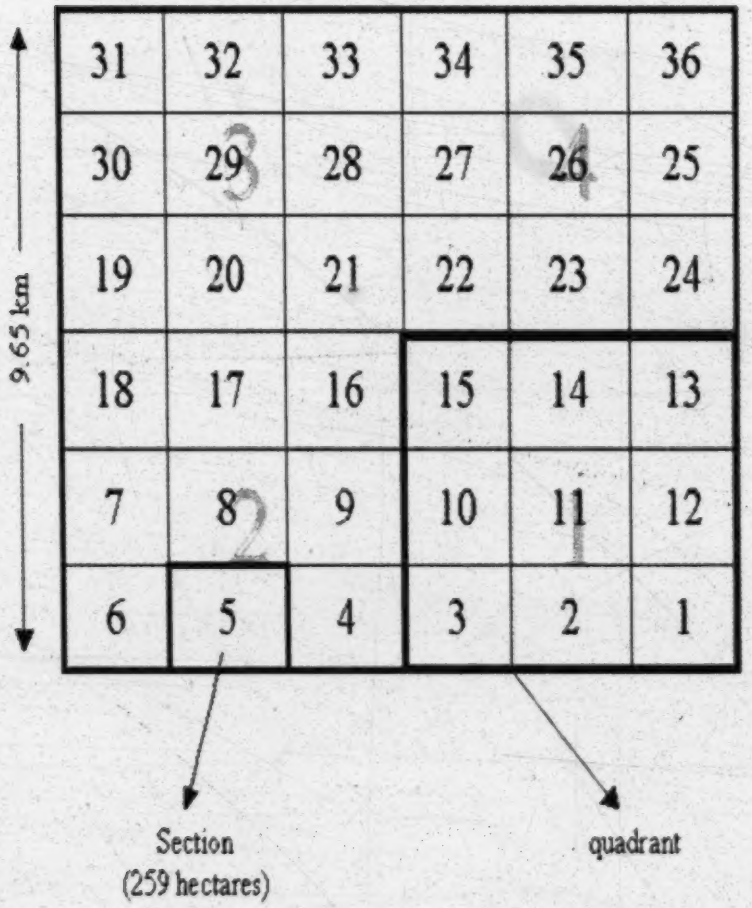

Figure 8. Unit of Analysis for Wildlife Accounting

[31] The homeland area of the HLFN is the main focus for this part of the study instead of their traditional area. With the large geographical scale involved with the traditional area, there is a large amount of data that needed to be extracted from the Alberta Vegetation Inventory. Given the time constraint, this study was unable to extract all the data. As such, it concentrated on developing wildlife accounts only for the homeland area.

Due to a lack of data for some of the exogenous variables in the original model (**equation [21]**), only crown closure, water access, new cut and river density were included and transferred in the final model for this study.[32] The following formula was used to calculate the probability of an area containing high moose populations:

$$\Pr ob(i) = \exp(\beta_k X_i) \Big/ 1 + \exp(\beta_k X_i) \qquad [22]$$

where X_i is a vector of k attributes with alternative i and β_k is vector of parameters or taste weights (Adamowicz, et al., 2004). There are several areas with high probabilities of having good moose habitats with the highest at 0.6701 and 0.6581 and the lowest at 0.0054.[33]

The results from the moose abundance model are then used as part of the independent variables found in the stated preference model. The model describes the probability of choosing site i as a function of several exogenous variables. The original function is:

> *Choice of site i = f (travel cost, moose abundance, new cut dummy, old cut dummy, no cut, water access dummy, no hunting, encounters, new and old logging roads access)* **[23]**

The travel cost, moose abundance and new cut variables highly influenced the behaviour of where Aboriginal hunters go hunting in the area. These variables are defined below:

Travel costs pertain to money spent on traveling to a hunting site. Travel cost was computed using the following formula:

> *Travel cost = [2*(RD + 3*NRD)*$0.589] + [1/90*1/3*(minimum wage)* 2*(RD + 3*NRD)]* **[24]**

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[32] Old cut for this particular analysis refers to those conducted between 1980-1995, and new cut refers to clear cut activities between 1996-2000.

[33] Results can be mapped on a spatial scale, however, was not presented in this thesis due to the sensitive nature of the information.

Where RD refers to total road distanced traveled in kilometres from the Heart Lake community to a quadrant and NRD stands for non-road distance. The $0.589/km refers to the cost of operating a vehicle in Canada as reported by the Canadian Automobile Association. Due to the sensitive nature of earnings of First Nation individuals, the regular minimum wage for the province of Alberta is used instead. Thus, the value for travel cost may not be the true value for time as individuals pursuing subsistence activities and having an irregular work schedule may have a different amount for income.[34]

Moose abundance refers to the predicted probability from the moose habitat model discussed earlier. New and old cut dummy, no cut, water access, and new and old logging road access are all dummy variables. **Table 4** presents the variables applied in the Adamowicz, et al. (2004) study.

The following formula was used to calculate the probability of choosing a hunting site:

$$\Pr ob(i) = \exp(\beta_k X_i) \Big/ \sum \exp(\beta_k X_j) \qquad [25]$$

the parameters are similar to the definition found for **equation [22]**.

[34] Income data for First Nations in Canada are often suppressed by Statistics Canada. Income distributions and related statistics are suppressed if the area from either the 100% or 20% databases is less than 250 persons or if the number of private households is less than 40 and if the quality of data is considered inadequate due to incompletely enumerated Indian reserves and Indian settlements.

Table 4. Independent Variables used in Predicting an Area is Visited by Hunters

Variable Name	Code	Description
Travel Cost	Computed using **equation [28]**	Money spent in travelling to hunting site
Moose Abundance	Probability ranging from 0 to 1.0	Derived from results of **equation [25]**
New cut	(0, 1)	Site has been harvested 5 or fewer years ago
Old cut	(0, 1)	Site has been harvested 10-15 years ago
No cut	(base)	No evidence of timber harvesting
Water access dummy	(0, 1)	Area is accessible by water
Road Access	(0, 1)	Access to road
No hunt constant *	1	Stay at home instead of hunting
Encounters*	1	Other people were encountered

Note: * -Variables that were not applied or transferred to this study's model. Data on these variables were not available and were assigned a value of zero. However, both variables are statistically significant at 5% level in the original paper and negatively related to hunters' choice of a site, thus not including them may contribute to overestimating the probabilities.

The data on some of the exogenous variables for the study area are not available, thus, the final model included moose abundance, which was derived earlier, the new and old cut dummy, water and road access dummies. The estimates derived from the stated preference model of Adamowicz et al. (2004) were used to derive new estimates for the probability that a hunter will visit a site to hunt for moose. The estimates from the original model are shown in **Table 5**.

Table 5. Original Parameter Estimates for Stated Preference Model Transferred to this Study

Variables	Parameter	t-statistic
Travel cost	-0.6721	11.32
Moose abundance	0.8295	5.788
New cut	-1.2783	11.05
Old cut	-0.5055	3.577
Water access	0.4703	3.499
Road access	0.10135	1.468

Note: Estimates were drawn from Table 4 of Adamowicz, et al. (2004) page 146.

Probabilities of a hunter visiting a site have high values of 0.11 and .08. The values are low because there are a number of alternative areas available to hunters; thus, several substitute sites are available to them. These probabilities are used to calculate welfare changes with Aboriginal hunters given a landscape change, which is discussed in the following section.

5.4. Simulating Effects of Forest Landscape Changes on Community Welfare

Adamowicz et al. (2004) assessed the impact of two new management situations on hunters' welfare and simulated the effects of forest landscape changes on the welfare of Aboriginal moose hunters. The authors estimated the change in the distribution of trips across hunting sites visited by Aboriginal hunters given the effects of two new harvest plans. The general change in their welfare measured through the changes in economic values for their hunting trips were also estimated. The changes in the landscape are a result of the changes reflected in the variable for percentage of clear cut that affects moose habitat quality and hunters' preferences of hunting sites. The results provide information on how Aboriginal hunters are affected by timber extraction activities in their areas.

Compensating variation (CV) was used to estimate the changes in hunters' welfare. CV is the amount of compensating payment necessary to offset a change in income brought about a change in status quo (Freeman, 2003). CV is defined as

$$V(M, P^0, q^0) = V(M - CV, P^1, q^1) \quad [26]$$

where P^0 are base prices, q^0, quality while P^1 and q^1 are new prices and quality. CV is deterministic, thus, in order to measure welfare, it must include the randomness (stochastic nature) in the utility, i.e.

$$V(M, P^0, q^0, \varepsilon) = V(M - CV, P^1, q^1, \varepsilon) \quad [27]$$

Thus, the estimate for a compensating variation in a random utility conditional logit model becomes;

$$CV = \frac{1}{\lambda_M}[\ln(\sum_{j \in C_n} \exp(V_j^1) - \ln(\sum_{j \in C_n} \exp(V_j^0))] \quad [28]$$

where λ_M is the marginal utility of income (Holmes and Adamowicz, 2003).

This research modified the approach applied by Adamowicz et al.'s (2004) in determining changes in the values of hunting trips since specific details of harvesting plans are unavailable from Al-Pac's Detailed Forest Management Plan. In particular, there are no specific data available on the future quantity to be clear cut and more importantly where exactly future harvests will come from, thus this study made a number of assumptions and extrapolated the available data on percentage of clear cuts for the area. One of these assumptions is that the forest company will continue cutting at 0.30% per unit area for the next 15 years (2000-2015). The study also assumed that these clear cuts could be harvested from any areas on the FMA included in the study. Each area has an equal probability of being chosen to be clear cut. To simulate clear cut locations, the

total number of areas out of 83 that are affected by clear cut activities is 17, based on averages of previous number of clear cut areas.[35] Thus, the average percentage clear cut is distributed on randomly determined cut areas.[36]

Welfare changes were then estimated for five-year intervals, where the base year contains no timber harvesting activities, i.e. percentage old clear cut was zero. **Figure 9** shows the changes in total economic values associated with different clear cuts. CV1 refers to the calculated compensating variation that relates welfare changes for each five-year interval from the base year (1990-earlier), while CV2 refers to the estimated compensating variation that relates welfare changes for each interval from the previous interval, say, from 1991-1995 to 1996-2000, instead of 1990-earlier to 1996-2000 unlike in CV1. Simply, CV1 is the change in welfare from the base year and CV2 is the change in welfare from the previous period. The dynamics behind this measure of economic value are further illustrated in equations **[29]** to **[30]**:

$$CV1 = \frac{1}{\lambda_M}[\ln(\sum_{j \in C_n} \exp(V_j^i) - \ln(\sum_{j \in C_n} \exp(V_j^0))] \qquad [29]$$

$$CV2 = \frac{1}{\lambda_M}[\ln(\sum_{j \in C_n} \exp(V_j^{i+1}) - \ln(\sum_{j \in C_n} \exp(V_j^i))] \qquad [30]$$

where i refers to the five-year period intervals, and 0 is for the base interval (earlier-1990). It is important to note here that for **equation [30]** i starts with the base interval,

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[35] Random number generator function in Microsoft Excel was used to determine these possible clear cut areas. For example, on average 17 out of the 83 areas are affected by clear cut, applying the random number generator for a range of 1 to 83, 17 areas are determined, and thus, the average percentage clear cut for each period are assigned.

[36] Due to time and data constraints, the characteristics and variability of stands in terms of the probability of an area being available for harvest was not addressed. This may have an impact on where clear cut can be implemented, thereby affecting the choice for hunting sites. For future research, this aspect may be included by calculating a timber supply model and relating it with the existing landscape of the study area.

where the initial calculation for welfare change for CV2 is based on the interval 1990 and earlier.

Figure 9 illustrates two results. One is the change in economic values given the changes from the base model (CV1) and the other is the change from every five-year intervals (CV2). The economic values as related by CV1 show that when clear cutting activities were introduced in the areas welfare decreased by $0.55 per hunting trip in the first period (1991-1995). The result seems reasonable given that all the areas, as assumed in this study, have not experienced any clear cutting until the new clear cutting activities were implemented; hunters will initially avoid these areas as their chances of coming across a moose is decreased. However, given that the areas have now been previously cut, the estimate for period 2 becomes positive. The succeeding periods also show that the changes are positive, albeit decreasing and become more stable in the long run, i.e. exhibiting that hunters may adjust their hunting behaviour given the continuing clear cutting activities. At the same time a new cut, which has a positive relationship with the quality of moose habitat (See **Table 6** for reference) may actually increase the appearance of moose in certain hunting areas.

In summary, relative to the base year, every period but the first is an improvement. Comparing period to period, the second period provides the largest benefit and then welfare starts to decline in magnitude after that.

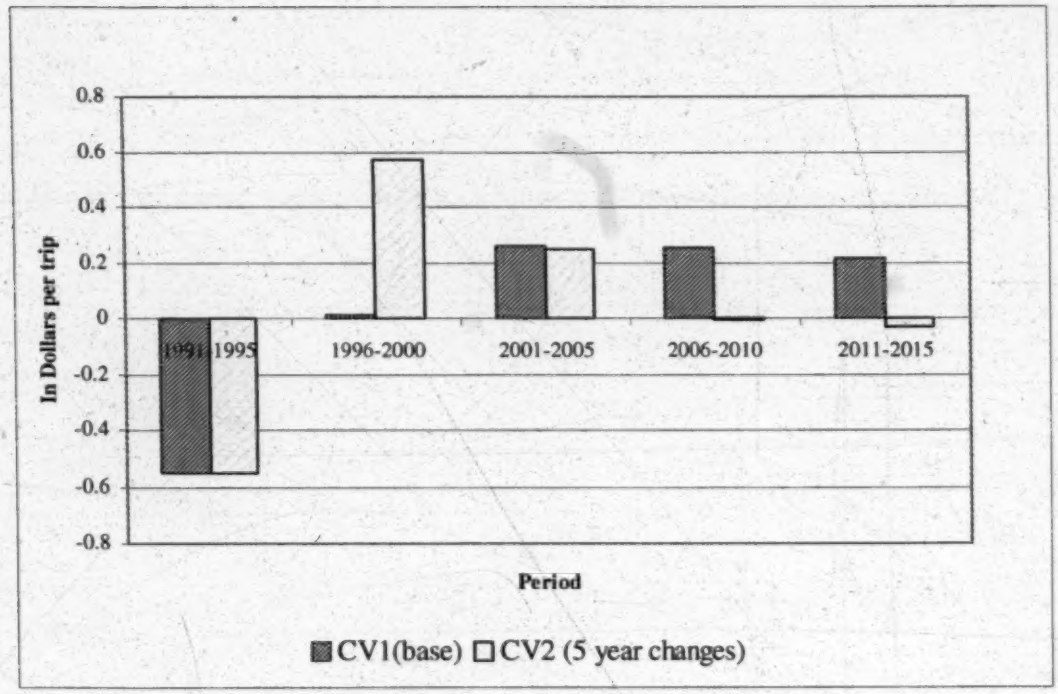

Figure 9. Change in Economic Values Associated with Changes in Landscape

Table 6. Changes in Economic Values Associated with Changes in Clear Cutting Activities on the HLFN Homeland Area

Period	Change Per Trip		Total Change Per Year	
	CV1 (Base)	CV2 (5-year periods)	CV1 (Base)	CV2 (5-year periods)
1991-95	-0.553	-0.553	-719.2	-719.2
1996-00	0.015	0.568	19.627	738.8
2001-05	0.260	0.245	338.07	318.44
2006-2010	0.252	-0.008	328.1	-9.971
2011-2015	0.219	-0.034	283.37	-44.73

Note: CV1 refers to the change in economic values given the changes from the base model (Earlier-1990) and CV2 are changes from every five-year intervals.

The second result that **Figure 9** exhibits are changes in economic values from one five-year interval to the other, i.e. CV2. The initial impact is similar to the first result, where welfare has decreased for period 1 (1991-1995). A similar change with the first result shows that from period 1 to period 2 (1996-2000) the value becomes positive, as hunters would have probably adjusted their behavioural patterns in terms of where they hunt. It is important to note though that calculations for the succeeding years continue to decrease from period 2 (1996-2000) onwards, this might exhibit a sign that the continuing clear cutting activities on the land decreases the general welfare of Aboriginal moose hunters.

The resulting low CV values may be attributed to the high number of substitute sites available to Aboriginal hunters; there are 83 possible sites to choose from. However, hunters may not consider all these 83 sites and do not have information on all of them. To illustrate how the number of available substitutes affects CV values, this study also simulated how CV values will change if there are fewer hunting sites available, i.e. where total number of sites is reduced by 25% (21 sites), 50% (42 sites) and 75% (63 sites).[37] **Appendix Table 4** provides a summary of these results. CV values increase as number of available substitute sites decline. Cutting down the number of sites from 83 to 63, increased total changes per year for both CV values (CV1 and CV2) ranging from 8% to 62%; with 41 sites, total values increased by as much as 88% (2001-2005); and with only 21 sites, by 49% (1991-1995).[38] The fewer substitutes available for the Aboriginal hunters, the more value they place on these sites given the landscape changes.

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[37] Hunting sites deleted from the available choices were randomly chosen. For the first scenario 25% of 83 sites were deleted; then 50% of 83 sites and 75% of 83 sites for the last scenario.

[38] There are also increases in CV values reaching up to more than a 100% (*See* **Appendix Table 4**).

From these results, predicted changes in hunting trips by Aboriginal moose hunters may also be derived.[39] Since this study is applying a benefit transfer approach, it does not have data on actual number of trips taken by Aboriginal hunters. Thus, the estimate determined by Dosman et al., (2001) for the highest average actual moose hunting trips taken in the 1999 hunting season of 20 trips was used. There are approximately 65 eligible Aboriginal hunters living in the area of the reserve, thus, there is a total number of 1,300 trips made per year and this value is assumed to be constant.[40] This value was multiplied with the probability of hunters visiting a specific area that was estimated earlier.

This study estimated the change in the number of trips to hunting areas using the following formula:

$$\textit{change in trips per area} = \textit{post-forestry harvest trip} - \textit{pre-forestry harvest trip} \quad [31]$$

Figure 10 shows that there are significant changes in the predicted number of trips per area given the changes in the landscape.[41] The results presented in this figure are only those for changes in hunting trips of period 1 (1990-1995) and period 2 (1996-2000) since actual data were used, i.e. percentage clear cuts and locations were identified given the data extracted from the Alberta Vegetation Inventory. A similar exercise can also be done for different welfare changes for the different time periods. Hunting trips can decrease by as much as 153 trips/year (62%) in one area for 1990-1995 and 107 trips/year (58%) for 1996-2000 given the landscape changes. Since this study assumed that the

[39] The study of Adamowicz, et al. (2004) estimated the predicted percent changes in trips of Aboriginal hunters given the two forest harvesting plans they simulated in their study. This study, however, estimated the change in the number of trips and not the percentage.
[40] The figure includes all male population that are 15 years and older.
[41] Areas where no changes in trip numbers occurred were not included in the figure.

total number of trips per year is held fixed, moose hunters tend to relocate to other probable hunting sites, as illustrated in the figure. This shows the predicted pattern of Aboriginal hunting by relating how they react to landscape changes. This of course may affect the quality of their hunting experience and also may affect their costs of travel. In the long run, the total number of trips may decline if hunting conditions decline in quality. This would generate a different kind of welfare loss than exhibited here.

This section showed that forest extraction activities affect the welfare of aboriginal moose hunters in the area. Despite of the small percentage of areas affected by clear cutting, it is evident that moose hunters experience changes in their levels of welfare. However, these effects are small and may not capture all the relevant changes occurring in the environment such as oil and gas related activities.

Aside from forest related activities, energy activities also affect hunting behaviour not only through seismic related activities that may affect moose movements, but also through road developments, construction of wells and other infrastructures and indirectly through the economic development activities that may displace culture and traditional habits of hunting by the Aboriginal people. The subsequent section discusses energy resource accounts.

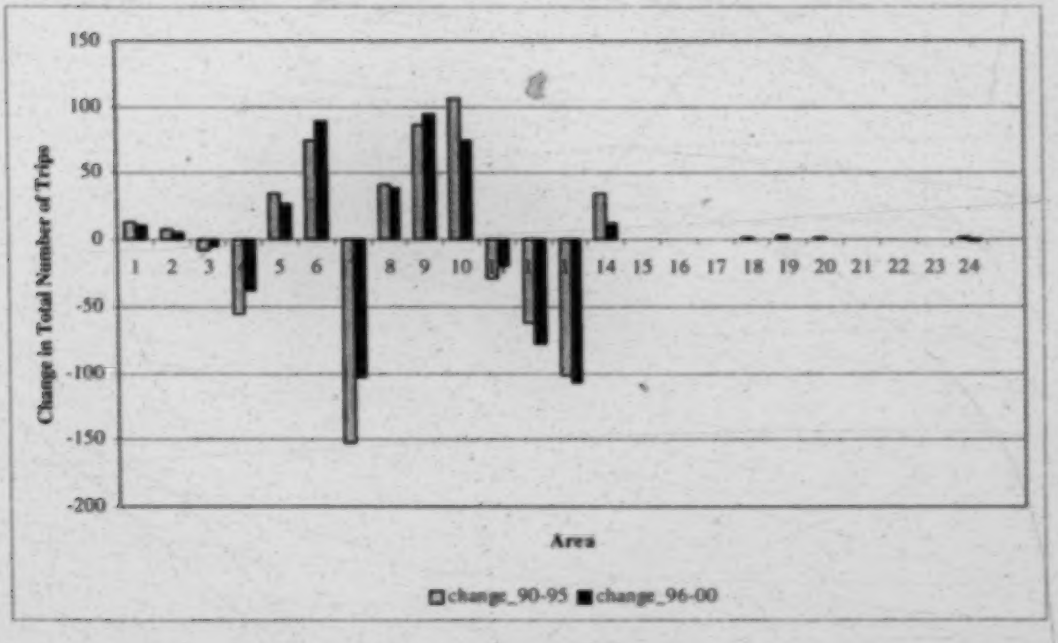

Figure 10. Changes in the Predicted Number of Trips Given Changes in Landscape Per Area [42]

5.5. General Description of Oil and Gas Operations in the Study Area

The following discussion presents the results for both physical and monetary accounts of oil and gas resources in the study area. It also relates the current activities to both the short-term and long-term sustainability of the resource in the area.

Canadian Natural Resources Limited (CNRL) is the main oil and gas company present in the Heart Lake traditional area. The company is based in Calgary, Alberta. A total area of 29,042 hectares of land on the traditional area that is 13% of the total area of the First Nation, contain some form of oil and gas operations, i.e., drilled wells (operational or abandoned), roads, and pipelines, etc..

[42] The resulting changes in predicted number of trips were amalgamated at a township level to fit the resulting estimates in the graph, thus having a total of 24 areas instead of the 83 areas used as level of analysis for this study.

Table 7 highlights the number and type of wells in the area based on well-ticket data generated from GeoScout.[43] The total number of oil and gas wells in the area is 942, 414 (44%) of which have a status of flowing gas.[44] The status of the rest of the wells may be 'abandoned,' 'suspended' or are 'water' wells. The average life index for reserve wells is 51.5 years, however, the range can be as short as one year to as long as 60 years.[45] The average surface loss factor for wells in the area is 5.25% and the average recovery factor for most of the wells is 54%.[46]

Given the lack of oil production activities in the area, the study no longer includes a resource account for this energy resource, and focuses on natural gas production. **Figure 11** shows a map of where gas production activities are conducted on the study area, and the amount of cumulative gas production (in thousands cubic meters) since 1997. The values have been aggregated at a township level. Cumulative production for non-associated flowing gas has been increasing for the last two decades in the area (See **Figure 12**).

The trends in production from the area are often influenced by the general trends found in the entire province. There have been sharp increases in production throughout the years. Periods of decline in production can be related to the province's drilling activities that were not able to offset the reduced output from Alberta's maturing conventional reserves (Alberta Energy Annual Report, 2004).

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[43] GeoScout exploration information system is software containing well information systems using maps and cross-section tools (http://www.geologic.com/geoscout).

[44] These natural gas wells refer to the non-associated type, which are natural gas from gas and condensate wells, in which there is little or no crude oil (http://www.naturalgas.org/naturalgas/processing_ng.asp).

[45] Reserve life index is the ratio of a pipeline's system supply reserves to annual sales expected, stated in years. It helps determine the rate of return for a pipeline and is often calculated by dividing the total reserves by the current production volumes (American Gas Association).

[46] Surface loss involves resource that was lost during extraction and recovery factor is the ratio of recoverable oil or gas reserves to the estimated oil or gas in place in the reservoir.

Table 7. Number and Type of Oil and Gas Wells Found on the Study Area

Code	Type of Wells	Number
ABO	ABD oil	19
AG	ABD gas	25
AGZ	ABD gas zone	26
AK	ABD whipstock	6
ARE	ABD re-entry	3
ARG	ABD re-entered gas	1
ASI	ABD steam jet	1
AUV	ABD observation	4
AWD	ABD water disp	1
AZN	ABD Zone	36
D&A	ABD and dry	174
D&C	Capped and dry	123
FG	**Flowing gas**	**414**
SBO	Suspended cr-BIT cycle	6
SG	Suspended gas	89
SSI	Suspended steam inject	1
SUS	Suspended	1
SWD	Suspended water disp	2
SWS	Suspended water source	1
UV	Observation well	2
WD	Water disposal	5
WI	Water injection	1
WSC	Water source	1
Total		**942**

Note: ABD - abandoned

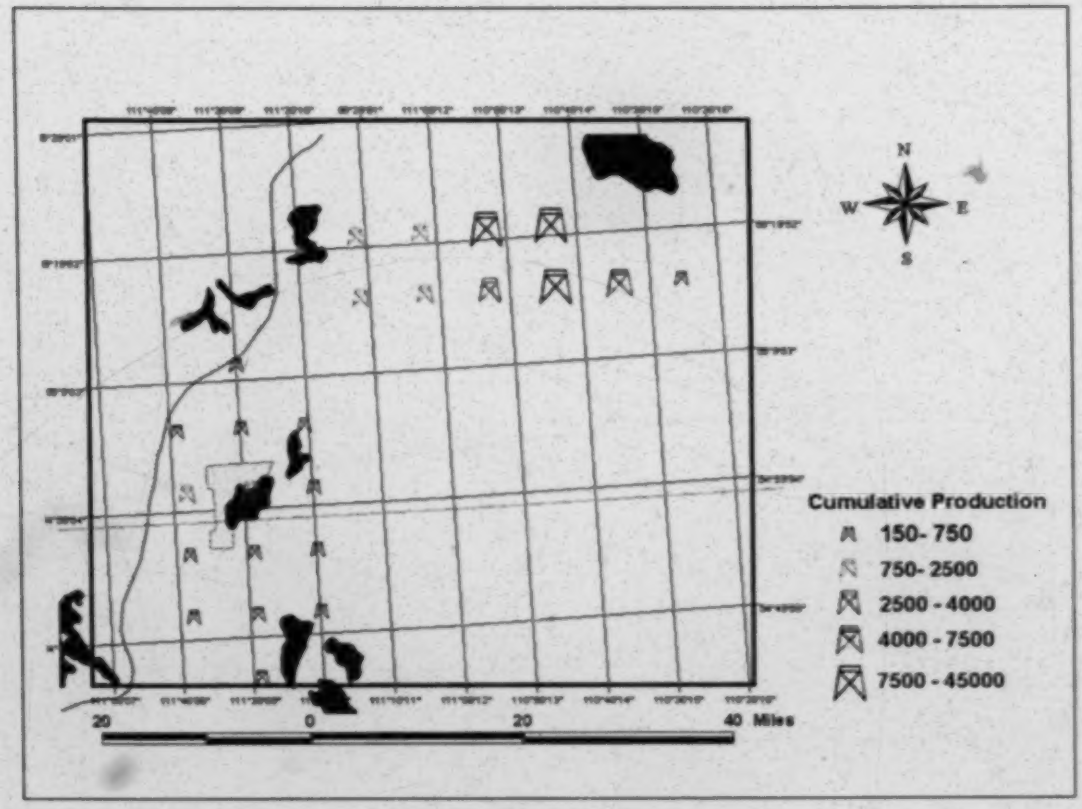

Figure 11. Map of Cumulative Gas Production (In '000 cubic meters) on Heart Lake First Nation [47]

[47] Map was generated using Arc View, Geographic Information System (GIS) desktop software from ESRI, used for mapping, data integration and analysis. Data on ultimate potential was derived from Alberta Energy and Utilities Board (2005).

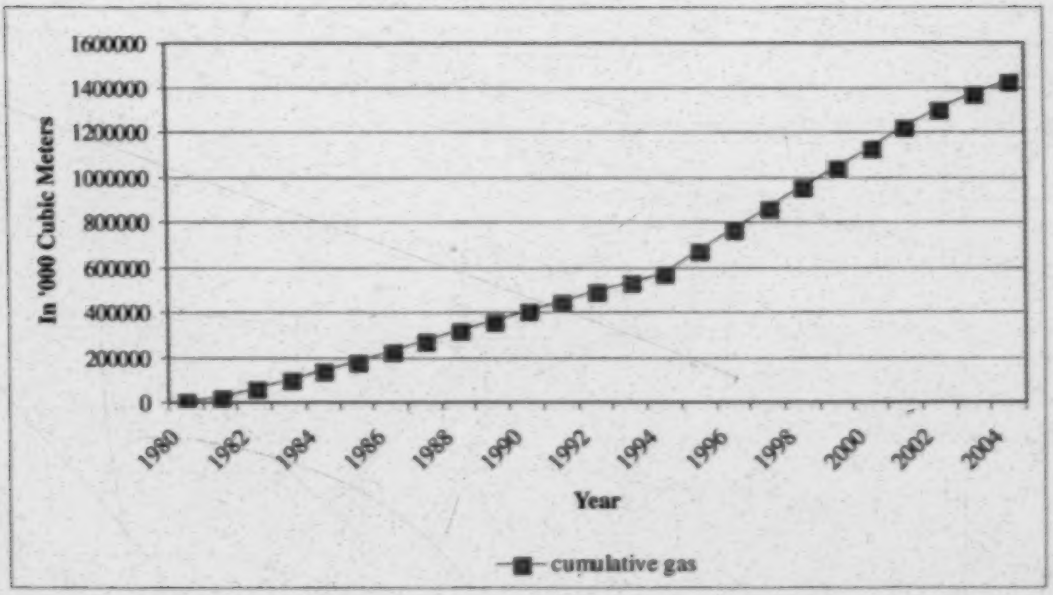

Figure 12. Cumulative Gas Production for the Study Site

Annual natural gas production in the area has steadily been increasing since 1988 and a sharp increase in 1995; however, by 1996 a downward trend ensued for following years. **Figure 13** shows these trends for annual gas production. Also trends in total revenue, product of market price and total production, show a decreasing trend. However, during some years like in 2003, revenue has increased despite the decrease in annual production, as brought about the by high gas prices.

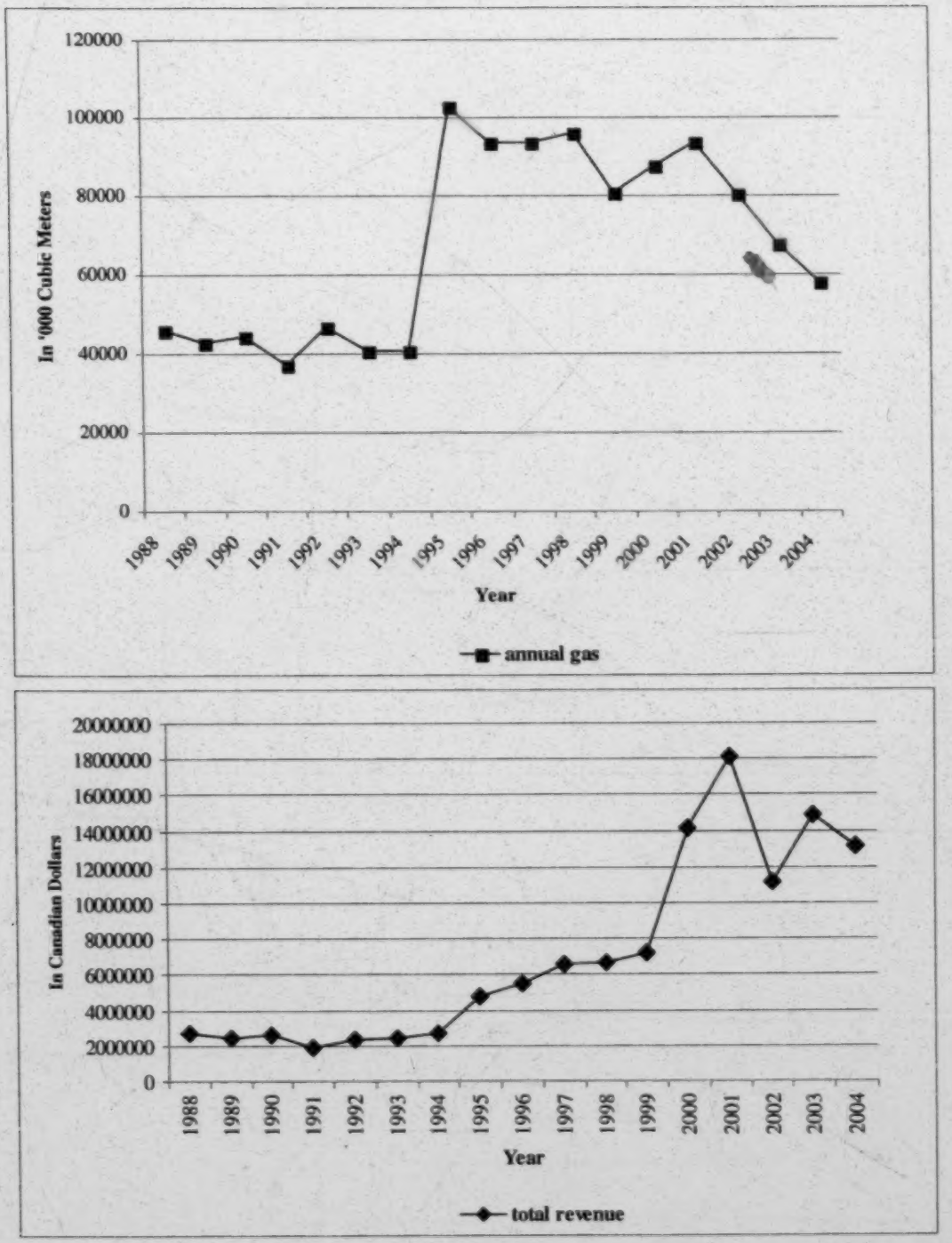

Figure 13. Trends in Annual Gas Production and Total Revenue for the Study Site[48]

[48] Data were extracted from GeoScout, 2004.

5.6. Energy Physical Account

The lack of area specific data with regards to opening stock, reserves and discoveries makes it difficult to construct a standard physical account for the study area. **Table 8** presents a physical account of remaining marketable gas in the area that includes forecasted values until the year 2015. **Figure 14** shows the trends in this physical account. These figures were derived from thematic maps generated by the Alberta Energy and Utilities Board (AEUB, 2005) on their report of the ultimate potential supply for natural gas and extrapolated using a simple moving average technique.[49] Ultimate gas in place refers to the volume of gas in the reservoir, recoverable gas is the volume that can be produced, and marketable gas is the volume that remains after processing. Remaining marketable gas is derived from the difference of the ultimate potential and cumulative production, which represents the volume available to meet future market demands (Alberta EUB, 2005).[50]

Reserve data were also derived from the ultimate potential for conventional natural gas reserves. There have been two published reports by the Alberta Energy and Utilities Board that estimated the ultimate potential for natural gas in the province of Alberta. The first one conducted in 1992 and the other in 2004. Alberta's total ultimate potential has increased by 43% since 1992. Thus, using interpolation, the 2004 value for ultimate potential was used to subtract 43% of its total to trace back the value for 1992.

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[49] The term *ultimate potential* refers to an estimate of the volume of resources that will be proven to exist in a geological basin, or in a specific area, after exploration has ceased. At any point in time, ultimate potential is the sum of resources that have been *discovered* and resources that are still *undiscovered* (National Energy Board, 2004).

[50] It is important to note that these are conventional natural gas from clastic and carbonate reservoirs that with improvement in technology and stable prices can be extracted (Alberta EUB, 2005).

Table 8. Actual and Predicted Physical Accounts for Gas Production in the Study Area (In Million Cubic Meters)

Period	Ultimate Gas in Place	Potential Marketable Gas	Marketable Gas	Remaining Marketable
1992	**114,449**	**37,456**	**24,693**	**10,253**
1993	117,972	38,609	25,453	10,569
1994	121,603	39,797	26,237	10,894
1995	125,291	41,004	27,032	11,224
1996	129,221	42,291	27,880	11,576
1997	133,185	43,588	28,735	11,931
1998	137,278	44,927	29,619	12,298
1999	141,198	46,210	30,464	12,649
2000	146,210	47,851	31,546	13,098
2001	150,290	49,186	32,426	13,464
2002	154,949	50,710	33,431	13,881
2003	158,016	51,714	34,093	14,156
2004	**163,662**	**53,562**	**35,311**	**14,662**
2005	168,050	54,998	36,257	15,055
2006	164,689	53,898	35,532	14,754
2007	161,395	52,820	34,821	14,459
2008	158,167	51,764	34,125	14,170
2009	155,004	50,729	33,443	13,886
2010	151,904	49,714	32,774	13,609
2011	148,866	48,720	32,118	13,336
2012	145,889	47,745	31,476	13,070
2013	142,971	46,790	30,846	12,808
2014	140,111	45,855	30,229	12,552
2015	137,309	44,937	29,625	12,301

Note: - Ultimate gas is volume of gas in reservoir; marketable gas is volume that remains after processing and remaining marketable is the difference between ultimate potential and cumulative production.

- Figures in **Bold font** for the year 1992 and 2004 are actual estimated values by the AEUB and the rest of the values were interpolated by this study.

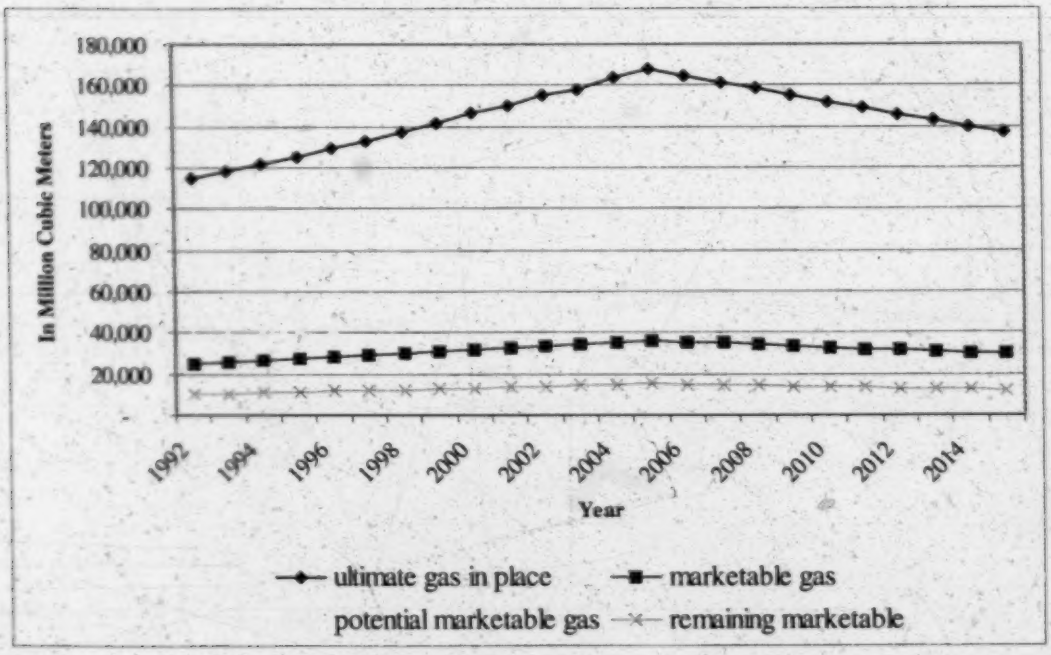

Figure 14. Trends in Natural Gas Production

The 2005 ultimate potential report also showed the rates of increase for initially established reserves for some given years (2000-2003), and applying 4-year moving averages, rates of annual increase per year from 1992-1999, 2004 and 2005 for ultimate potential reserves were determined. Further, the 2005 report also stated that conventional resources would decline starting in 2006 at a rate of 2 % every year. This factor was used to forecast production from 2006 onwards. These percentages were used to determine the different levels of natural gas reserve and production.

A sharp increase in gas production was forecasted for 2005. Operations start to decrease in the succeeding years. This was probably generated by high prices and a high

level of drilling activity and increasing natural gas royalties caused by pipeline expansion in the province, specifically for 2004 (Alberta Energy Annual Reports). Reserves and production quantities and sector operations in general are closely linked with price changes.

These results however must be interpreted with caution, as the trend shows that production in general is stable, stock may not be able to supplement the rate of extraction farther into the future. The volatility of oil and gas prices can easily change the trend presented here. Historical data have shown sharp movements in the industry trends.

5.7. Energy Monetary Account

Due to the limited site-specific data available for the development of monetary resource accounts, specifically those involving associated capital expenditures and discovery, this research employed several assumptions, specifically for calculating values of associated capital as discussed in the next paragraph.

Monetary accounting for oil and gas production generally involves the following relationship:

*Closing stock = [Opening stock – (depletion rate*opening stock)]*price* **[32]**

Using thematic maps from the AEUB report on Alberta's Ultimate Potential for Conventional Natural Gas (2005) was a crude method to use to estimate the actual reserve potential for the area, however, consistent data on gas production are difficult to obtain. **Appendix C** presents a sample of one of the thematic maps used in the study. **Table 9** shows the estimates derived from those maps given the relevant areas for the study that include low, medium and high estimates. This table is a more detailed version

Table 9. Low, Medium and High Estimates for Gas Production (In Million Cubic Meters)

Year	Potential Marketable Gas			Marketable Gas			Remaining Marketable Gas		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
1992	23,094.00	37,456.00	51,818.00	18,266.00	24,693.00	31,119.00	7,849.00	10,253.00	12,657.00
1993	23,804.97	38,609.12	53,413.27	18,828.34	25,453.20	32,077.03	8,090.64	10,568.65	13,046.66
1994	24,537.60	39,797.37	55,057.13	19,407.80	26,236.56	33,064.24	8,339.64	10,893.91	13,448.19
1995	25,281.85	41,004.46	56,727.07	19,996.46	27,032.34	34,067.12	8,592.59	11,224.34	13,856.08
1996	26,074.81	42,290.56	58,506.31	20,623.65	27,880.20	35,135.63	8,862.09	11,576.39	14,290.68
1997	26,874.58	43,587.69	60,300.81	21,256.22	28,735.34	36,213.30	9,133.91	11,931.46	14,729.00
1998	27,700.64	44,927.47	62,154.31	21,909.58	29,618.59	37,326.41	9,414.67	12,298.20	15,181.73
1999	28,491.49	46,210.15	63,928.81	22,535.10	30,464.20	38,392.08	9,683.45	12,649.31	15,615.17
2000	29,502.94	47,850.61	66,198.28	23,335.09	31,545.68	39,755.00	10,027.22	13,098.36	16,169.51
2001	30,326.07	49,185.64	68,045.22	23,986.14	32,425.81	40,864.16	10,306.98	13,463.81	16,620.64
2002	31,266.18	50,710.40	70,154.62	24,729.71	33,431.01	42,130.95	10,626.49	13,881.19	17,135.88
2003	31,885.25	51,714.46	71,543.68	25,219.36	34,092.94	42,965.14	10,836.90	14,156.03	17,475.17
2004	33,024.00	53,562.00	74,100.00	26,121.00	35,310.50	44,500.00	11,224.00	14,662.00	18,100.00
2005	33,909.46	54,998.13	76,086.81	26,821.37	36,257.26	45,693.16	11,524.94	15,055.12	18,585.31
2006	33,231.27	53,898.17	74,565.07	26,284.94	35,532.12	44,779.29	11,294.44	14,754.02	18,213.60
2007	32,566.64	52,820.21	73,073.77	25,759.24	34,821.48	43,883.71	11,068.56	14,458.94	17,849.33
2008	31,915.31	51,763.80	71,612.29	25,244.06	34,125.05	43,006.03	10,847.18	14,169.76	17,492.34
2009	31,277.00	50,728.53	70,180.05	24,739.18	33,442.54	42,145.91	10,630.24	13,886.37	17,142.49
2010	30,651.46	49,713.95	68,776.45	24,244.39	32,773.69	41,302.99	10,417.64	13,608.64	16,799.64
2011	30,038.43	48,719.68	67,400.92	23,759.51	32,118.22	40,476.93	10,209.28	13,336.47	16,463.65
2012	29,437.66	47,745.28	66,052.90	23,284.32	31,475.86	39,667.40	10,005.10	13,069.74	16,134.38
2013	28,848.91	46,790.38	64,731.84	22,818.63	30,846.34	38,874.05	9,805.00	12,808.34	15,811.69
2014	28,271.93	45,854.57	63,437.20	22,362.26	30,229.41	38,096.57	9,608.90	12,552.18	15,495.46
2015	27,706.49	44,937.48	62,168.46	21,915.01	29,624.82	37,334.64	9,416.72	12,301.13	15,185.55

Note: Estimated values for 2004 are based on thematic maps generated by the AEUB's report on the Ultimate Potential for Conventional Natural Gas (2005), while the rest of the values were interpolated.

of the figures found in **Table 8**. Medium estimates simply refer to the average of the low and high estimates reported on the maps. In particular, the thematic maps in the AEUB report showcase colour-coded grids relevant to the level of analysis that this research used, i.e. townships and regions. The maps present a range of values from a low of zero to a high of 60,000 million cubic meters. The average (medium) estimates were the values used for the study's analysis.

The computation for the total value of gas in the study area involves the calculation of rent, in this case, the Hotelling rent as discussed in previous sections.[51] Economic rent generated by gas production is the net difference between the international commodity prices for gas less all costs of production (including exploration, development, operating, capital and transportation costs). Simply, it is the net revenue generated from production.

The study applied the current rent method in deriving monetary accounts. This method is based on one of the several methods being applied around the world, as discussed by the National Research Council in "Nature's Numbers: Expanding the National Economic Accounts to Include the Environment" (1999). It employs a net present value approach based on the Hotelling valuation principle where;

$$Vt = \left[P_t - a_t - \frac{rK_t}{q_t} - \frac{R_t D_t K_t}{q_t} \right] R_t \qquad [33]$$

$$Additions_t = \left[P_t - a_t - \frac{rK_t}{q_t} - \frac{R_t D_t K_t}{q_t} \right] A_t \qquad [34]$$

[51] It is important to note that Hotelling valuation tends to provide a systematic overvaluation of reserves (NRC, 1999).

$$depletions_t = \left[P_t - a_t - \frac{rK_t}{q_t} - \frac{R_t D_t K_t}{q_t} \right] q_t \qquad [35]$$

$$revaluations_t = V_t - V_{t-1} + depletions_t - additions_t \qquad [36]$$

Where:
V_t= value of mineral reserves
P_t = price of gas per cubic meter
a_t= average cost of production per cubic meter
R_t= total quantity of reserves
r = average rate of return on capital (assumed to be 10%)
K_t= value of associated capital
q_t= total quantity extracted (annual production)
D_t = depreciation of associated capital (assumed to be between 5% to 17%)
A_t = quantity of discoveries of new reserves
Additions = value of discoveries of new reserves
Depletions – value of depletions
Revaluations = change in value of reserves corrected for depletions and additions

Equation **[33]** defines the total value of stock as the net price times the quantity of reserves. Equations **[34]** and **[35]** also show that additions and depletions are calculated in a similar way, i.e., net price times the quantity of addition or depletions. The inclusion of revaluations is an important element in monetary accounts; it is calculated as a residual; the change in the value of the stock through price changes that are not taken into account in the depletion and addition calculations.[52] This is important given the volatility of gas prices, as it will include any errors in the depletions and additions. This important component could not be included in this study due to the lack of accurate data.

Energy production is market driven, prices affect demand for gas and its production, as can be observed by the values generated by this study. Energy prices can fluctuate from one year to the next, thus, the real value of energy assets is not always best represented by the per unit rent in a single year. A number of countries use multiple-year

[52] A simpler definition of revaluation is provided by Lange and Hassan (2001), which refer to the opening stock multiplied by the difference in the oil and gas prices.

moving average per unit rents in calculating asset values. Canada for example, uses a five-year multiple-year lagged moving average for its energy prices. This approach reduces price volatility and better represents the long-term value of mineral assets (Lange and Hassan, 2001).

Operating costs and data on associated capital expenditures relating to natural gas extraction per cubic meter for CNRL are available in annual reports. However, the information is aggregated for the company's entire gas operations in Canada, therefore is not specific to the study site. In order to get a glimpse of the total value of the gas accounts for the study area, this study took the percentage share of the revenue that the company derives from gas operations in the area from the overall revenue that the company generates and used this percentage to derive the probable value of the associated capital that the company expends in the area. Total quantities extracted are figures derived from GeoScout relating to annual gas production in the area. Some of the other assumptions made in this study include; 10% rate of return for associated capital, depreciation rates for associated capital were randomly generated for the different years from an average low rate of 5% to as high as 17%, as reported by the CNRL annual report (1999). Data on prices for gas and actual production were extracted from GeoScout (GeoScout, 2005).

Table 10 shows the results for the total value of the gas operations in the study area. Average rent generated from 1997 to 2003 is $0.10/cubic meter; an average of $0.25 if including the forecasted years from 1997-2015. The average of $0.10/cubic meter is higher but not far from Smith's (1992) average estimate for Alberta's gas rent of $0.03/cubic meter from 1980-1988 ($0.14/cubic meter at 2003$). The rent estimate is

also close to Anielski's (1996) calculations of average gas rent of $0.05/cubic meter for the period of 1980 to 1996 ($0.11/cubic meter at 2003$).

Total value reaches a peak in year 2006 and starts to decline afterwards (See **Figure 15**). The trend may be a result of Alberta EUB's assessment that after the year 2006, conventional resources will decline by 2% every year. **Appendix Table 5** shows details of how total values and economic rents were calculated.

Table 10. Total Value and Rent Calculations for Natural Gas Operations

Period	Total Value In Canadian Dollars	Total Rent C$/'000 cubic meters	Total Rent C$/cubic meter
1997	1,662,670,076	44.05	0.04405
1998	4,978,996,089	52.32	0.05232
1999	10,018,303,957	77.68	0.07768
2000	15,240,001,566	167.83	0.16783
2001	5,910,744,240	58.67	0.05867
2002	11,279,637,115	99.16	0.09916
2003	26,732,959,998	204.48	0.20448
2004	15,570,903,688	121.78	0.12178
2005	42,173,912,868	346.12	0.34612
2006	55,290,602,136	408.19	0.40819
2007	51,999,005,788	391.30	0.39130
2008	49,815,771,194	369.54	0.36954
2009	45,976,884,589	348.15	0.34815
2010	42,025,556,619	329.52	0.32952
2011	45,132,510,081	363.78	0.36378
2012	44,058,967,822	354.42	0.35442
2013	40,835,858,790	350.31	0.35031
2014	39,723,084,142	350.86	0.35086
2015	37,835,749,477	353.01	0.35301

Note: Actual price and production data were used for calculations from 1997 to 2004. For the remaining years, values were interpolated. Total value is estimated using the formula presented in **Equation [36]**.

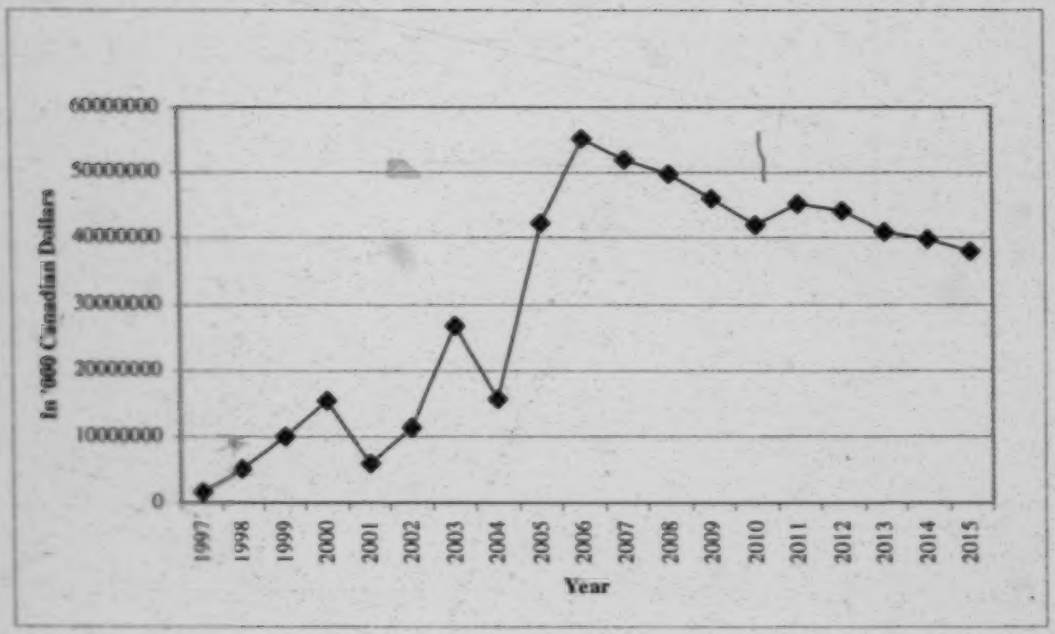

Figure 15. Trend of the Total Values for Natural Gas on the Study Area [53]

This study also conducted a sensitivity analysis of how the amount of ultimate potential gas in place affect the total values for natural gas production. The analysis was conducted in order to assess whether the trend presented in **Figure 15** continues regardless of changes in the start of the year of decline in ultimate potential gas in place. **Figure 16** shows the results of this assessment where the predicted 2% decline in ultimate potential gas in place occurs in different years. Five different scenarios were analysed, 2% decrease begins in 2006 (Scenario 1), 2007 (Scenario 2), 2008 (Scenario 3), 2015 (Scenario 4) and 2030 (Scenario 5). The first three years were close to each other to

[53] The general trend for energy accounts shows that the study area possibly follows the realization of the Hubbert's peak, where the apex comes in the year 2006 and production starts to decline in the succeeding years. However, this is only speculative as the peak is a data artefact. The Hubbert peak theory, also known as peak oil, concerns the long-term rate of conventional oil and other fossil fuels production and depletion and predicts that future world oil production will reach a peak (apex) and then rapidly decline (Deffeyes, 2001).

determine whether a difference of a year will move the peak and results show that the peak does not change. For all the first three scenarios, the peak occurs in the year 2006. However, when the 2% predicted decline begins further in the future, specifically 2030, total value continues to increase and the peak is not as prominent compared to the other scenarios. Once the peak point is reached however, total value decreases regardless of when the predicted decline occurs. The results illustrate the importance of knowing when the potential decline in gas reserves occurs to effectively predict the trend in production levels, and subsequently its values.

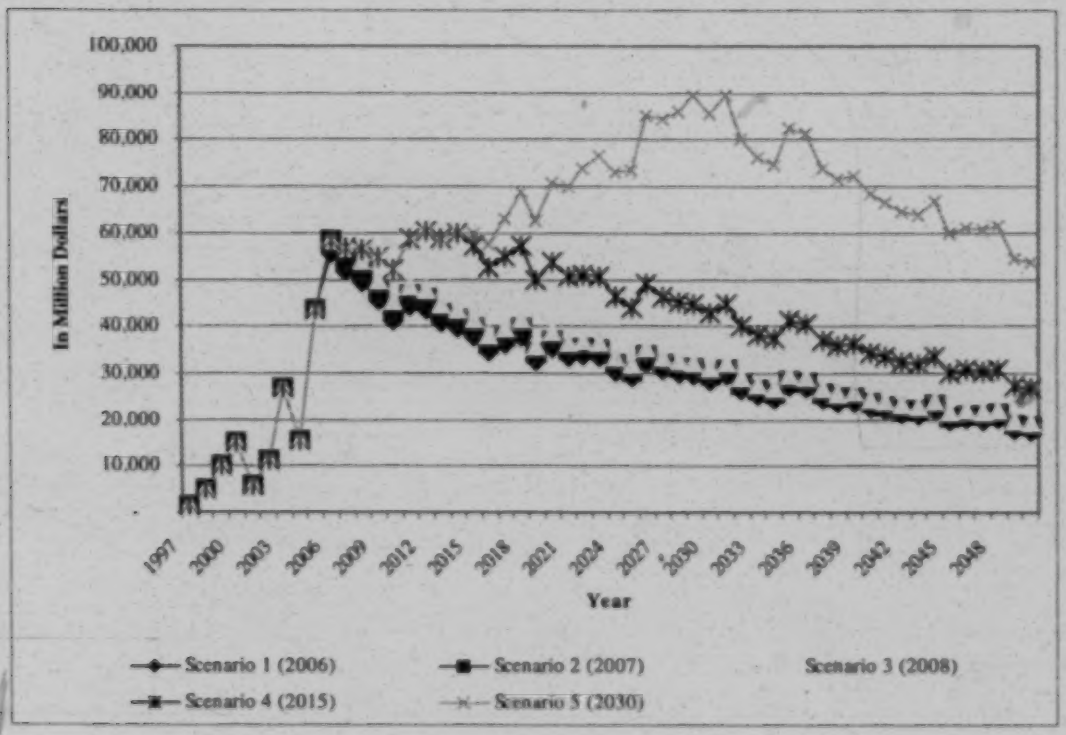

Figure 16. Simulated Total Values for Natural Gas Production

Energy related activities are present in the area and the production of natural gas will continue to increase in the short-term, especially with anticipated increase in gas prices. With the assumption that ultimate potential estimates start to decrease by 2006, the general trend for total economic value for natural gas on the study area initially exhibits an upward trend until 2006, except for the periods of 2001 and 2004, where values have decreased from the previous years due to the decreases in gas prices. The values for the rent computed also decline. Sustainability for non-renewable resources is assessed by the amount of rent that is saved and reinvested on human-made capital. The following section discusses how the results from the resource accounts relate to assessing sustainability.

6.0. Assessing Sustainability of Resource Use

Increasing the growth of the economy seems to provide a solution to some of the present ills that society faces, which include poverty, overpopulation, illiteracy and others (Daly, 2005). However, achieving economic growth highly depends on the quantity and quality of available resources, both natural and human-made capital. The following discussion relates the results of the resource accounts to the concept of sustainability and with values of Aboriginal people.

6.1. Sustainability and Forest Resources

The general trend of the forest resource accounts show that the resource appears to be being used in a sustainable manner. The application of the annual allowable cut (AAC) contributes to the sustained harvest and growing stock is may be increasing. It is important to reiterate, though that when actual harvest data were used instead of the values for AAC, harvests exceeded growth. This is potentially explained by the fact that AAC for a forest management area can be redistributed to other management units and that AAC can be done in 5-year increments.

Further, valuation for moose hunting exhibited small fluctuations for forecasted economic values. Welfare losses are small except when areas are clear cut for the first time. The result suggests that the quality of moose habitat is affected by clear cut operations in the area initially in a negative way then changes in economic values become positive for a time. This is due to the positive relationship that moose have with newly clear cut areas. This result however must be interpreted with caution, as the Benefit Transfer Approach applied in this study employed many assumptions.

Based on the results of both timber and wildlife accounts, it may be concluded that forest resources are being used in a sustainable manner for the short-term. The preceding statement comes with a caveat. Although, resource accounts present a good picture of trends of resource use in the area, the forest resource account developed for this study is incomplete. Non-timber values, both use and passive uses, other than moose hunting, contribute to the total economic value of forest resources; specifically, wildlife like elk, fish, geese and other animals; bush harvests such as mushrooms, plants for medicinal purposes and values relating to cultural and spiritual aspects of Aboriginal life, all offer a fair share in the total value of the forestland. On the other hand, long-run sustainability of forest resources cannot be discerned with certainty as resource policies and management institutions may change in the future and this can affect the current dynamics of the forest management in the area.

On the institutional side, Al-Pac in 2000 initiated an integrated land management (ILM) program as identified in its Forest Stewardship Report (FSR). This was prompted by Al-Pac's concern about the current rate of exploration and development of crude oil and gas activities in the area. The establishment of new mines and mining facilities are deleted from an FMA area, and other areas near these facilities are severely affected by the industrial activities (Ross and Smith, 2002). Al-Pac believes that linear disturbances such as road building may be reduced substantially with proper coordination with oil and gas industries and the First Nation.

In pushing this initiative forward, Al-Pac has committed itself to involve the community of Heart Lake. It is laudable that Al-Pac has made progress in the area in terms of their efforts on networking with the community by assigning a liaison officer for

the First Nation. This enables the Aboriginal people to become more active participants in the decisions related to managing forest resources in the area. Al-Pac also promotes Aboriginal business opportunities and joint ventures. One specific example of a project Al-Pac has implemented in the area is the Aboriginal Education Partnership Program, where it pays full tuition for an Aboriginal student a year for post-secondary education.

Al-Pac applied for a forest certification under the Forest Stewardship Council (FSC) in 2001, however, the distributed oil and gas wells on their FMA land proved to be an obstacle. The energy industry is a major barrier to the certification of forest management (AWA, 2001). This barrier, however, was overcome by Al-Pac, as it has been awarded FSC certification. Al-Pac reached a milestone by having 5.50 million hectares of public land managed by the company certified and has the largest FSC certified forestland worldwide -- 22.8% of the global total (Canadian Boreal Initiative, 2005; Al-Pac, 2005).[54] Al-Pac's certification made Canada the leading country in the world for FSC-certified forests, and is also the first in Alberta and first in the boreal forest of western Canada (Al-Pac, 2005).

6.2. Sustainability and Energy Production

It is evident that energy production related activities are present on the homeland and traditional areas of the HLFN. From the total number of wells, abandoned or operational, pipelines and road networks, the study area contains considerable oil and gas related activities. Annual gas production from the area has been increasing since 1988 and trends are estimated to continue until 2006; afterwards it is projected to decline.

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[54] Areas affected by oil and gas activities on Al-Pac's FMA totalling to 300,000 hectares were excluded from the area, as it is "*...not managed according to Al-Pac's ecosystem management principles*" (Al-Pac, 2005).

Assessing sustainability for non-renewable resources involves more than estimating resource accounts, physical and monetary, but includes consideration of how much rent is being reinvested into human-made substitutes, from education to technological advancement and other development projects (Arrow, et al., 2004). The average economic rent estimated by this study for natural gas is at $0.10 per cubic meter. Reinvestments of energy revenues in Alberta may come in the form of rebates and tax refunds and tax cuts (Anielski, 1997).

The government collects royalties, fees and other taxes from oil and gas companies, which are in turn invested in provincial projects (Anielski, 1997), and are put into funds like the Alberta Heritage Savings Trust Fund (AHSTF).[55] The Alberta government seemed to have anticipated the theoretical argument made by Hartwick, i.e., that *"future generations of Albertans can benefit from today's production and sale of a finite stock of non-renewable resources if (some of) the economic rents generated by these activities are saved and invested in alternative forms of capital that will yield sustained flows of benefits over time"* (Plourde, 2006; page 12).[56]

Although, AHSTF serves as an investment vehicle for the province, this study was not able to fully assess the extent of the level of sustainability on how non-renewable resource is used in the study area. There is lack of direct evidence and information on how rents generated from energy production in the Heart Lake region are reinvested in

[55] The AHSTF was a fund set up to put a portion of the revenues from oil and gas sales for future generations of Albertans especially when non-renewable resources run out. A portion of the revenues collected by the province is transferred from the government's general revenues to the Fund, where these are invested in revenue-yielding instruments "... for the benefit of future generations of provincial residents" (Scarfe and Powrie 1980, p.166).

[56] It earns around $1.10 billion each year from investment revenues (Plourde, 2005). The revenues are used for education and health care programs and help diversify the economy such as through medical research programs (Plourde, 2005; Malkinson, 2001).

the community. Also, reinvestments to a large extent are a government activity, an institutional aspect that makes it difficult to trace investments going to the community.[57]

Economic sustainability (for renewable and non-renewable resources) is an important aspect in assessing overall sustainability of a region. Institutions play an important role in attaining and maintaining sustainability. Effective institutions can help prevent excessive resource depletions, and thus, promote higher genuine investment (Arrow, et al., 2004). The following sub-section relates how institutions are important in resource management.

6.3. Sustainability and Institutions

Effective institutions can motivate stakeholders in implementing sustainable resource management. This can be done thru standardizing harvesting levels (e.g. setting AAC for forest industries); regulating harvesting operations; and formulating policies that curb resource depletion and exploitation (e.g. silvicultural activities for forest companies and reclamation duties for energy companies).

In particular, the Alberta government endorses integrated resource management (IRM), as a way to achieve sustainable development (Alberta Environment, 2005). IRM is a strategy that companies such as Al-Pac, try to implement. IRM can help reduce the impact of an industry's extraction activities on another and may lessen resource-use conflicts. Given these benefits, it seems best for industries to implement IRM but companies often find it difficult to employ because of the high transactions costs that it may entail. Since, there are currently no specific provisions in resource-use laws that state IRM is a management requirement (Kennett, 2002), perhaps including IRM as a

[57] HLFN made a claim that they lack appropriate compensation from the oil and gas industries in 2002 (See HLFN report, 2002). Three years have past since the claim and the community might have formed an agreement with the energy company, which might have been kept confidential.

provision will help encourage industries to participate more actively in the initiative. IRM can thus become an institutional tool to help curb cumulative impacts and play an important role in sustainability.

6.4. Sustainability and Aboriginal People

A number of criteria and indicators can be applied in assessing some level of sustainability, such as natural resources accounts, the amount of reinvestment of rents to social and economic development projects for the community and income generated from natural resources. There is a rather intricate web of complexity that Aboriginal communities have in relation to how they themselves value natural, human-made and cultural capital. The ties they have on the land and the utility they derive from it are not easily identified nor discerned and given current information we can at best speculate on the levels of their economic well-being.

In general, based on the graphs and tables generated by this research, extraction activities for both forest and gas resources seem to be done in a (weakly) sustainable manner. For economic reasons, members of the Aboriginal community are perhaps concerned with the non-declining stock of resources on their land. However, given Aboriginal lifestyle and history, Aboriginal communities will also be concerned with the sustainability of social and cultural factors, where current generations have the opportunity to impart their traditional knowledge and skills to future generations.

It seems that given the unique cultural history of the Aboriginal community at Heart Lake, for cultural identity to be sustained, there should be some consideration of strong sustainability for certain resources, such as moose and other wildlife. Although, strong sustainability was not assessed in this study, having (strong) sustainability for

wildlife resources seem to be a requirement; wildlife may not necessarily be substituted with human-made capital. Traditional and cultural activities such as hunting and fishing have been a lifestyle for the Aboriginal people and the maintenance of their culture is somewhat guaranteed in the Indian Act and Treaty rights (*See* **Section 4.0**). Although, certain kinds of compensation for economic losses that are incurred and can be given to the current generation, the transfer of traditional lifestyle such as hunting skills might not happen for future generations.

Aboriginal people may consider natural resources as wealth and treat human-made capital, to a certain extent, as more of a complement than a substitute (Daly, 2005). Human-made capital may not be able to support the lifestyle and culture that Aboriginal people have been accustomed to. Thus, in including Aboriginal values in measurements of sustainability, the analysis should also include culture and lifestyle of the community. Therefore, the use of only the standard criteria and indicators for sustainability is not sufficient, albeit necessary, to assess the overall level of sustainability in the Aboriginal community.

7.0. Summary and Conclusions

Sustainability of resource use is an important issue. Sustainability ensures that future generations are able to enjoy the benefits of resources in a similar way to those in the present (intergenerational equity). The success of achieving sustainability rests with how much or how the present generation uses resources (consumption level), estimated through resource accounts; how economic rent is spent, saved and invested; and the attributes of existing institutions that govern resource use. This thesis set out to determine how resource accounts can be developed that include economic values of Aboriginal people; are resources currently being used in a sustainable manner and what kind of sustainability indicators are relevant to Aboriginal communities. The study attempted to determine whether sustainability of resource use is achievable given the multiplicity of use of the forestland and can it be estimated at a scale of the Aboriginal community level -- the Heart Lake First Nation (HLFN).

Forest related resources such as timber and wildlife exhibit a pattern of sustainable resource use. Despite the lack of detailed data, results showed that net changes for timber resources are increasing, i.e., where growth rate of physical stock is non-declining. Economic rent estimated for forest products are stable. Clear cutting activity does have an impact on the total welfare of Aboriginal hunters, but seems to be small. Implementing specific wildlife habitat enhancement programs in the future by the forest company may counteract any negative effects of clear cutting on moose population.

The results for energy accounts exhibited initially increasing values for gas production and projected to decline by 2006. Calculations for economic rent also showed

a similar trend. Determining long-run trend for energy production relies heavily on how future prices will evolve. Assessing sustainability for non-renewable resources requires tracing where energy rents are expended. Since parts of energy revenues go to the Alberta Heritage Savings Trust Fund, it is difficult to trace the exact percentage of the Trust that goes directly to the study area and the community. Overall, energy accounts may be decreasing, but the economy could be sustainable as long as reserve growth exceeds the depreciation of the stock. This growth could come from technical change from investments.

Resource accounts should include both use and non-use values and marketed and non-marketed values. In the case of the Aboriginal community of Heart Lake, the history and lifestyle of the community have relied heavily on the benefits that they get from the land in terms of hunting and trapping activities, bush harvests, as well as economic and social benefits through education, skills transfer and economic development projects that may provide them employment and income. Economic values derived from timber and other marketed products are important as they add to the economic growth of the members of the community.

The presence of effective institutions in the resource management area is important and has been partly discussed in this research. Poorly defined property rights may lead to excessively rapid resource exploitation, especially if exploitation does not require much prior investment, thus, markets will fail to properly price natural resources (Arrow, et al., 2004). The failure of the market to accurately capture the value of the resource will lead to government and firms undervaluing investment goods.

The issue of intragenerational equity may also be deemed important, as activities that promote increased sustainability have an impact on the general welfare of the current generation.[58] This type of equity may be of concern for the current stakeholders on the traditional land. According to Pearce and Vanegas (2002), due to the contextual nature of sustainability "*actions which seem rational and sustainable to one party acting in isolation may actively conflict with the rational actions of other parties in the interconnected real world*" (*page 6*). For this study, it seems that both forest and energy industries benefit from the resources based on the values of the revenues and rent they incur. For the Aboriginal community, results from the wildlife accounts show that hunting behaviour is minimally affected by forest harvesting activities on the forestland. These results may imply intragenerational equity, however, it is not the same as saying that equity is actually achieved, as no direct inquiry was conducted by this study.

This research was a challenging exercise that attempted to measure economic sustainability that includes economic values of Aboriginal people. Despite of the assumptions made and the difficulties of obtaining site-specific data, the results of the study suggest that there is evidence of sustainable resource use in the area, but are subject to a number of caveats and future research issues.

[58] Intragenerational equity relates that current generations ensure that finite resources are used to benefit people of today with minimum environmental impact and take into account the relative scale of the potential impacts and distribution of risks and benefits (http://www.fathom.com; Cambridge University Press).

8.0. Limitations and Recommendations for Further Research

This thesis faced several limitations because of time and data constraints. As for data constraints, this study faced a number of challenges, thus applying a number of assumptions with regards to developing forest and energy accounts. The following discussion presents the limitations faced by this study including recommendations for further research.

8.1. Methods used for Forest Resource Accounts

Developing resource accounts at a sub-regional scale was a daunting task, especially when detailed data are not readily available at this level. Data for timber accounts were generally accessible especially for the amount of timber harvested. However data for fire incidences were not available given the scale of the study. This thesis used an average incidence rate based on provincial statistics; thus, timber destroyed by fire may have been overestimated or underestimated. Using rates that are specifically based on the study area will provide more accurate estimates.

With regards to developing wildlife accounts, the Benefit Transfer Approach has shortcomings as a methodology. The estimated welfare values may have been overestimated or underestimated. In particular, not including "no hunt" and "encounter" variables from the original model may have overestimated the probability of a hunter choosing a site. The inclusion of these variables will have an impact on the overall assessment of hunting sites. Also, the hunting probability model may be extended to include independent variables reflecting energy-related activities, such as number of wells, presence of roads and pipelines, and other related activities; of course no longer employing benefits transfers but through a survey method. Such a model can potentially

improve the estimates of the overall impact of economic activities on the hunting behaviour of the Aboriginal people.

The application of a simple random sampling on both the selection of which sites are to be clear cut in developing welfare values and on the simulation of hunting sites, has an effect on estimated welfare values. Random sampling does not accurately reflect actual hunting behaviour. Further, as noted earlier (See **Footnote 51**) consideration of stand characteristics is important in making clear cut decisions and was not included in this thesis, future studies should include this aspect as it offers a more realistic model of the process of decision-making.

Data is also lacking on other use and non-use values for forest resources by the Aboriginal people, which contribute to underestimating the total value of forest resources. The inclusion and measurement of other services provided by natural resources are important. Personal interviews with the aboriginal community may provide estimates of these values, which this study was unable to do due to time and logistical constraints.

8.2. Methods used for Energy Resource Accounts

Data on natural gas production are not readily available. The assumptions made by this study for non-renewable accounts may have either overestimated or underestimated values. Associated capital was related to revenue percentage, but actual value for associated capital expended on gas operations on the study area could be larger or smaller than the amount estimated in the calculations. Acquiring a set of data on actual capital expenditures for future research may provide a more accurate approximation of economic values for energy resources.

8.3. Assessing Sustainability

A survey could determine the trade-offs that the community members are willing to make between economic growth and development, sustainable use of resource and cultural values. The results from which may lead to more concrete evidence on the level of sustainability of resource use in the area, therefore leading to a more comprehensive analysis. This component may be conducted in future research.

Overall, due to time constraints, this study was only able to focus on the homeland area of the Heart Lake First Nation, particularly for developing wildlife accounts. An extension of this research can be conducted in the future for the entire traditional area, including the parts in the province of Saskatchewan. The results may or may not exhibit the same resource use patterns as this study generated.

Despite of the shortcomings of this academic exercise, a general assessment of sustainability of resource at the scale of the study area was developed and values for physical and monetary resource accounts were estimated. Results of the study should help policymakers to improve the degree to which sustainability is achieved.

9.0. References

Adamowicz, W., T. Beckley, D.H. MacDonald, L. Just, M. Luckert, E. Murray, and W. Phillips.1994. "Search of Forest Resource Values of Aboriginal Peoples: The Applicability of Non-market Valuation Techniques." *Rural Economy Staff Paper* 94-08. University of Alberta. Edmonton, Canada.

Adamowicz , Wiktor L. 2002. "Economic Indicators of Sustainable Forest Management: Theory versus Practice." *Journal of Forest Economics.* 9(1):27-40.

Adamowicz, Wiktor, Peter Boxall, Michel Haener, Yaoqi Zhang, Donna Dosman, and Juanita Marois. 2004. "An Assessment of the Impacts of Forest Management on Aboriginal Hunters: Evidence from Stated and Revealed Preference Data." *Forest Science,* 50(2); 139-152.

Alberta Government. 2003. "Mines and Mineral Act." Internet Download. http://www.gov.nl.ca/hoa/statutes/f23.htm

Alberta Wilderness Association. 2001. "New Report Shows Alberta Policies are a Disadvantage to Forest Companies" News Release. Internet Download. http://www.albertawilderness.ca

Alberta Pacific Forest Industries, Inc. 2005. "Alberta-Pacific Awarded Forest Stewardship Council Certification." Internet Download. http://www.Al-Pac.ca/Company_News/Al-PacFSCCertificationNewsRelease.htm.

_____. 2001. "Forest Stewardship Report." Internet Download. http://www.Al-Pac.ca

_____.1999. "Detailed Forest Management Plan." Internet Download. http://www.Al-Pac.ca.

Anielski, Mark and Sara Wilson. 2001. "The Alberta GPI Accounts: Forests." *Pembina Institute for Appropriate Development. Report Number 20.* Drayton Valley, Alberta.

Armstrong, Glen. 1998. "A Stochastic Characterization of the Natural Disturbance Regime of Alberta's Boreal Forest: A Simple Process Producing Complex Outcomes." *Sustainable Forest Management Network (SFMN) Working Paper SES-3.* University of Alberta, Edmonton, Alberta.

_____. 1999. "A Stochastic Characterization of the Natural Disturbance Regime of the Boreal Mixedwood Forest with Implications for Sustainable Forest Management." *Natural Research Council Canada.* 29(4). Reprinted from *Canadian Journal of Forest Research.*

Arrow, Kenneth, et al. 2004. "Are We Consuming Too Much?" *Journal of Economic Perspectives,* 18(3):147-172.

Arrow, Kenneth, Partha Dasgupta and Karl-Goran Malër . 2003. "Evaluating Projects and Assessing Sustainable Development in Perfect Economies." *Environmental and Resource Economics.* 26:647-685.

Asheim, Geir B. 2000. "Green National Accounting: Why and How?" *Environment and Development Economics.* 5: 25-48.

Ayres, Robert U., Jeroen C.J.M. van den Bergh & John M. Gowdy, 1998. "Viewpoint: Weak versus Strong Sustainability." *Tinbergen Institute Discussion Papers.* 98-103. Tinbergen Institute, Netherlands.

Barzel, Yoram. 1989. "Economic Analysis of Property Rights." Cambridge University Press, United Kingdom.

Baumol, William J. and Wallace E. Oates. 1988. *The Theory of Environmental Policy.* 2nd Edition. Cambridge University Press. Cambridge, United Kingdom.

Baytas, Ahmet and Farahmand Rezvani. 1993. "Forest Resource Accounting in Ghana, 1970-1987." Center for Economic Research in Africa. Montclair State University. New Jersey.

Berkes, F., P.J. George, R.J. Preston, A. Hughes, J. Turner and B.D. Cummins. 1994. "Wildlife Harvesting and Sustainable Regional Native Economy in the Hudson and James Bay Lowland, Ontario." *Arctic,* 47(4): 350-360.

_____, A. Hughes, P.J. George, R.J. Preston, B.D. Cummins and J. Turner. 1995. "The persistence of Aboriginal Land Use: Fish and Wildlife Harvest Areas in the Hudson and James Bay Lowland, Ontario." *Arctic* 48:81-93.

Berkes, Fikret., Iain Davidson-Hunt, Tracy Ruta, and John Sinclair. 2002. "Scientific and First Nation Perspectives of Non-Timber Forest Products: A Case Study from the Shoal Lake Watershed, Northwestern Ontario." *Sustainable Forest Management Network (SFMN) Final Project Report.* University of Alberta, Edmonton, Alberta

Bodden, Ken R. 1982. "Subsistence Activities in Little Buffalo, Alberta." Alberta Environment.

Boxall and Beckley. 2002. "An Introduction to Approaches and Issues for Measuring Non-Market Values in Developing Economies." *In Uncovering the Hidden Harvest: Valuation Methods for Woodland and Forest Resources.* Earthscan Publications Ltd. U.K.

Bromley, D.W. 1991. *Environment and Economy: Property Rights and Public Policy.* Basil Blackwell Ltd. Oxford, United Kingdom.

Cairns, Robert D. 2004. "Principles of Green Accounting for Renewable and Non-Renewable Energy Resources." *Energy Policy.* 32:261-267.

Callan, Scott J. and Janet M. Thomas. 2004. *Environmental Economics and Management: Theory, Policy, and Applications.* 3rd Ed. South-Western, U.S.A..

Campbell, Bruce M. and Martin K. Luckert (ed). 2002. *Uncovering the Hidden Harvest: Valuation Methods for Woodland and Forest Resources.* Earthscan Publications Ltd. U.K.

Canadian Boreal Initiative. 2005. "Unlikely Alliance Applauds Al-Pac Forest Stewardship Council Certification: New FSC certification is Alberta Milestone." Internet Download. http://www.borealcanada.ca/news_e.cfm?p_id=293.

Coase, Ronald H. .1960. "The Problem of Social Cost." *Journal of Law and Economics,* 3;1-44.

Committee of International Development Institutions on the Environment (CIDIA): Workshop on Environmental and Natural Resource Accounting. Summary Record, Nairobi, 24-26 February 1992. *Environmental Economics Series Paper No. 3.* United Nations Environment Program (UNEP). Internet Download. http://www.unep.org/unep/products/eeu/ecoserie/ecos3/ecos38.htm

Costanza, Robert, Ralph d'Arge, Rudolf de Groot, Stephen Farberk, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert O'Neill, Jose Paruelo, Robert G. Raskin, Paul Suttonkk and Marjan van den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature.* 387:253-260.

Cuevas, A. 1999. "A Model for Analyzing Common Pool Situations in Natural Resources: Institutional Arrangements in Fishery." Unpublished Undergraduate Thesis. University of the Philippines, Los Baños, Laguna.

Daly, Herman E., 2005. "Economics in a Full World." *Scientific American.* September 2005. 293 (3). 100-107.

Da Motta, Ronaldo and Claudio Ferraz do Amaral. 2002. "Estimating Timber Depreciation in Brazilian Amazon." Institute for Applied Economic Research (IPEA) and Santa Ursula University. Rio de Janeiro, Brazil.

Dasgupta, P. and K.G. Malër . 1994. "Poverty, Institutions and the Environmental – Resource Base." *World Bank Environment Paper No. 9.* World Bank. Washington D.C.

_____. 1990. "The Environment and Emerging Development Issues." *Development Economics Research Programme No. 28.* London School of Economics. Clarendon Press. United Kingdom.

Deffeyes, Kenneth S. 2001. *Hubbert's Peak: The Impending World Oil Shortage.* Princeton University Press. New Jersey, USA

Department of Justice Canada. 2003. Canada Petroleum Resources Act. Internet Download. http://www.laws.justice.gc.ca

_____. 2003. Forestry Act. Internet Download. http://laws.justice.gc.ca/en/F-30/

Dosman, Donna, Michel Haener, Wiktor Adamowicz, Juanita Marois and Peter Boxall. 2001. "Assessing Impacts of Environmental Change on Aboriginal People: An Economic Examination of Subsistence Resource Use and Value." *Project Report 02-01.* Department of Rural Economy, University of Alberta.33 p.

Downing, Mark and Teofilo Ozuna, Jr. 1996. "Testing the Reliability of the Benefit Function Transfer Approach." *Journal of Environmental Economics and Management,* 30:316-322.

Economy and Environment Program for Southeast Asia (EEPSEA). "Valuing the Characteristics of a Tropical Forest. Special Paper." http://www.eepsea.org

Falls Brook Center. 2002. Full Cost Accounting Principle. Internet Download. http://www.web.net/nben/envnews/members/fullcost.htm

Fast, Helen and Fikret Berkes.1994. "Native Land Use, Traditional Knowledge and the Subsistence Economy in the Hudson Bay Bioregion." A Technical Paper prepared for the Hudson Bay Programme. Natural Resources Institute, University of Manitoba.

Funston, Bernard W. and Eugene Meehan. 1998. *Canada's Constitutional Law: In a Nutshell.* 2nd Edition. Carswell Thomson Professional Publishing. Ontario, Canada.

Francisco, Herminia. 1992. "Valuation Framework for Natural Resources." *Environment and Natural Resource Accounting Project Report :Phase I.* Manila, Philippines.

Freeman, A. Myrick. 2003. *The Measurement of Environmental and Resources Values: Theory and Methods.* 2nd Edition. Resources for the Future. Washington D.C.

Grafton, R. Quentin and Robert W. Lynch. 1998. "British Columbia's Stumpage System: Economic and Trade Policy Implications." *Canadian Public Policy Supplement.* 41-50.

Gomez-Lobo, Andres, 2001. "Sustainable Development and Natural Resource Accounting in a Small Open Economy: A Methodological Clarification." *Estudios de Economía.* 28(2): 203-216.

Haener, M., D. Dosman, W.L.Adamowicz and P.C. Boxall. 2001. "Can Stated Preference Methods be used to Value Attributes of Subsistence Hunting of Indigenous Peoples: A Case Study in Northern Saskatchewan." *American Journal of Agricultural Economics.* 83(5):1334-1340.

Haener, Michel K. 1998. "Regional Forest Resource Accounting: A Northern Alberta Case Study Incorporating Fire and Price Risk." Unpublished MSc thesis, Department of Rural Economy. University of Alberta, Edmonton, Alberta.

Haener, Michel. K. and Wiktor L. Adamowicz. 2000."Regional Forest Resource Accounting: A Northern Alberta Case Study." *Canadian Journal of Forest Research.* 30(2):264-273.

Haley, David and Martin K. Luckert.1990. "Forest Tenures in Canada: A Framework for Policy Analysis." *Information Report E-X-43.* Forestry Canada. Ottawa, Canada.

_____.1998. "Tenures as Economic Instruments for Achieving Objectives of Public Forest Policy in British Columbia." *In The Wealth of Forests: Markets, Regulation, and Sustainable Forestry.* Edited by Chris Tollefson. UBC Press, Vancouver, Canada, pp. 123-151.

Harris, Roger and Anshuman Khare. 2002. "Sustainable Development Issues and Strategies for Alberta's Oil Industry." *Technovation.* 22:571-583.

Hartwick, John M.. 1990. "Natural Resources, National Accounting and Economic Depreciation." *Journal of Public Economics* 43:291-304.

_____.1993. "Forest Economics, Deforestation and National Accounting." *In Toward Improved Accounting for the Environment.* Ernst Lutz (editor). The World Bank, U.S.A. pp. 289-314.

_____ and Anja Hageman.1993. "Economic Depreciation of Mineral Stocks and the Contribution of El Serafy." *In Toward Improved Accounting for the Environment.* Ernst Lutz (editor). The World Bank, U.S.A. pp. 211-235.

Heart Lake First Nation. 2002. "Requests to the Department of Indian Affairs Specific Claims Branch for the Validation of a Specific Claim Pertaining to the Primrose Lake Air Weapons Bombing Range."

Hickey, Clifford. 1999. "Whitefish Lake First Nation Land Use and Occupancy Study." *Sustainable Forest Management Network (SFMN) Project Report.* University of Alberta, Edmonton, Alberta.

Holmes, Thomas P. and Wiktor L. Adamowicz. 2003. "Chapter 6: Attribute-Based Methods." In A Primer on Nonmarket Valuation. Patricia A. Champ, Kevin J. Boyle and Thomas C. Brown (editors). Kluwer Academic Publishers. Netherlands.

Indian and Northern Affairs Canada. 2003. "Treaty No. 6." Internet Download. http://www.ainc-inac.gc.ca/pr/trts/trty6

_____.2003. 'Grievance on Creation of Cold Lake Air Weapons Settled English Bay, Alberta." July 12, 2002. Internet Download. http://www.ainc-inac.gc.ca/nr/prs/m-a2002/2-02168_e.html.

International Institute for Sustainable Development (IISD). 2001. "Integrating Aboriginal Land Values into Land Use and Resource Management." Final Report: January 2000-June 2001.

Javier, Esmyra P. 2003. "Do Institutions Affect Performance of Marine Protected Areas? Evidences from the Field." *Economy and Environment Program for Southeast Asia (EEPSEA) Research Report 05*. Singapore.

Karjala M.K., E. Sherry, and S.M. Dewhurst. 2004." Criteria and Indicators for Sustainable Forest Planning: A Framework for Recording Aboriginal Resource and Social Values." *Forest Policy and Economics*. 6:95-110.

Kasper, Wolfgang and Manfred E. Streit. 1998. *Institutional Economics: Social Order and Public Policy*. The Locke Institute. Edward Elgar Publishing Limited. Gloucester, United Kingdom.

Kennett, Steven A. 2002. "Integrated Resource Management in Alberta: Past, Present and Benchmarks for the Future." *Canadian Institute of Resources Law Occasional Paper No. 11*. University of Calgary, Alberta, Canada.

_____.2002. "Reinventing Integrated Resource Management in Alberta: Bold New Initiative or Déjà vu All Over Again?" *Wild Lands Advocate* 10(5):4-8, October 2002.

Kipping, Kerry. 2001. "First Nations Land Management Act: A New Legislative Approach to Reserve Land Management." *In Aboriginal Land Management*. A paper delivered at an Insight Conference in Ontario, Canada. November 19-20, 2001.

Krieger, Douglas J. 199_."Economic Value of Forest Ecosystem Services: A Review". *The Wilderness Society*.

Kriström , Bengt. 199_. "Harold Hotelling (1925) on Depreciation." Department of Forest Economics, Umea, Sweden.

_____. 1996. "On the Incorporation of Non-market Outputs of Forests into National Accounting Systems." Paper presented at the International Symposium on the Non-market Benefits of Forestry. Edinburgh, United Kingdom.

_____. 1998. "Valuing Forests." Paper presented in Managing Human-Dominated Ecosystems. Missouri Botanical Garden. U.S.A.

Kriström , B. and K. Skanberg. 2001. "Monetary Forestry Accounting including Environmental Goods and Services." *Investigación Agraria: Sistemas y Recursos Forestales* 1: 7-26.

Lange, Glenn-Marie, Rashid Hassan, and Kirk Hamilton. 2003. "Environmental Accounting in Action: Case Studies from South Africa." With contribution from Moortaza Jiwanji. Edward Elgar Publishing Limited.

Malër , Karl-Goran. 1991. "National Accounts and Environmental Resources." *Environmental and Resource Economics*. 1(1):1-15.

Mattsson, Leif. 1990b. "Moose Management and the Economic Value of Hunting Towards Bioeconomic Analysis." *Scandinavian Journal of Forest Research.* 5:575-581.

_____ 1990a. "Hunting in Sweden: Extent, Economic Values and Structural Problems." *Scandinavian Journal of Forest Research*. 5:563-573.

Mekonnen, Alemu. 2000. "Valuation of community forest in Ethiopia: A Contingent Valuation Study of Rural Households." *Environment and Development Economics.* 5: 289-308.

Mollo, Clotilde N. 2003. "Forest Regulations and Policy Objectives in Cameroon: An Economic Analysis." Unpublished Graduate Thesis. Department of Rural Economy. University of Alberta. Edmonton, Alberta, Canada.

Morris, Eugene, Chief of Heart Lake First Nation. Personal Interview. 4 November 2003.

National Aboriginal Forestry Association. 1993. "Forest Lands and Resources for Aboriginal People." An Intervention submitted to the Royal Commission on Aboriginal Peoples. Ontario, Canada.

National Research Council. 1999. *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment.* National Academic Press, Washington D.C. William D. Nordhaus and Edward C. Kokkelenberg *(Editors).*

Nickell, S.J. 1974. "On the Role of Expectations in the Pure Theory of Investment." *Review of Economic Studies.* 41(1);1-20.

Notzke, Claudia. 1994. "Aboriginal Peoples and Natural Resources in Canada." Centre for Aboriginal Management Education and Training (CLAMET) and Captus Press Inc.York, Ontario.

O'Faircheallaigh, Ciaran.1996. "Negotiating with Resource Companies: Issues and Constraints for Aboriginal Communities in Australia." *In Resources, Nations and Indigenous People: Case Studies from Australia, Melanesia and Southeast Asia.* Edited by Richard Howitt. Oxford University Press, Australia. pp. 184-201.

Owens, Dennis. 2000. "The Search for Aboriginal Property Rights." *Policy Series No. 4. Frontier Centre for Public Policy.* Manitoba, Canada.

Pearce, David and Giles Atkinson.1995. "Measuring Sustainable Development" *In Handbook of Environmental Economics.* Bromley, Daniel W (ed). Blackwell Publishing Oxford, United Kingdom: 166-181.

Pearce, Annie R. and Jorge A. Vanegas. 2002. "Defining Sustainability for Built Environment Systems." *International Journal of Environmental Technology and Management, Special Issue on Sustainability and the Built Environment*, 2(1); 94-113.

Pearse, Peter H.1998. "Economic Instruments for Promoting Sustainable Forestry: Opportunities and Constraints." *In The Wealth of Forests: Markets, Regulation, and Sustainable Forestry.* Edited by Chris Tollefson. UBC Press, Vancouver, Canada, pp. 19-41.

Pearson, Angela M. 2001. "Macroeconomic Indicators of Sustainability for Alberta." Unpublished MSc Thesis. Department of Rural Economy. University of Alberta. Edmonton, Alberta.

Perrings, Charles and Jeffrey R. Vincent. 2003. *Natural Resource Accounting and Economic Development.* Edward Elgar Publishing Limited. UK and USA.

Plourde, Andre. 2005. "Natural Revenues and Equalization: A Partial Overview of Selected Issues." Paper prepared for the Expert Panel on Equalization and Territorial Formula Financing. Department of Economics, University of Alberta. Edmonton, Alberta.

Poulus, Christine. 2000. "Improving the Reliability of the Benefit Transfer Method: A New Approach and an Application to Malaria Prevention." Center for Environmental and Resource Economic Policy. North Carolina State University. USA.

Pozler, Greg. 2002. "Aboriginal Peoples and Environmental Policy in Canada: No Longer at the Margins." *In* Canadian Environmental Policy: Context and Cases. Van Nijnatten, D. and R. Boardman (eds). Oxford University Press, United Kingdom.

Reinhardt, F. 1994. "Alberta-Pacific Forest Industries Inc." A Case Study prepared for a call discussion at Harvard Business School, Boston: Publishing Division, Harvard Business School. N9-794-099.

Repetto, R. W. Magrath, M. Wells, C. Beer and F. Rossini. 1989. *Wasting Assets: Natural Resources in the National Income Accounts.* Washington, D.C.: World Resources Institute.

Rosenberger, Randall S. and John B. Loomis. 2003. "Chapter 12: Benefit Transfer." *In A Primer on Nonmarket Valuation.* Patricia A. Champ, Kevin J. Boyle and Thomas C. Brown (editors). Kluwer Academic Publishers. Netherlands

Ross, Monique. 2002. "Legal and Institutional Responses to Conflicts Involving the Oil and Gas Forestry Sectors." *Canadian Institute of Resources Law Occasional Paper No. 10.* University of Calgary, Alberta, Canada.

Ross, Monique M. and Peggy Smith. 2002. "Accommodation of Aboriginal Rights: The Need for an Aboriginal Forest Tenure." *Sustainable Forest Management Network (SFMN) Synthesis Report.* University of Alberta, Edmonton, Alberta.

Schlager E. and E. Ostrom. 1992. "Property Rights Regimes and Natural Resources: A Conceptual Analysis." *Land Economics.* 68:249-62.6

Schneider, R.R., J.B. Stelfox, S. Boutin, and S. Wasel. 2003. "Managing the Cumulative Impacts of Land Uses in the Western Canadian Sedimentary Basin: A Modeling Approach." *Conservation Ecology.* 7(1): article 8.

Senbel, M., T. McDaniels, and H. Dowlatabadi. 2003. "The Ecological Footprint: A Non-monetary Metric of Human Consumption applied to Northern Alberta." *Global Environmental Change.* 13:83-100.

Smith, Roger S.1992. "Income Growth, Government Spending, and Wasting Assets - Alberta's Oil and Gas." *Canadian Public Policy.* 18(4): 387-412.

Staples, Ken, Al-Pac's Liaison Officer to Heart Lake First Nation. Personal Interview. 4 November 2003.

Statistics Canada. 2004. "Community Profile Statistics." http://www.statcan.ca

Stevenson, Mark. 2002. "Heart Lake First Nations Traditional Land Use Relevant to the Rio Alto Kirby Project." Draft Final Report. Golden Associates Limited. Alberta, Canada

Timoney, Kevin and Peter Lee. 2001. "Environmental Management in Resource-rich Alberta, Canada: First World Jurisdiction, Third World Dialogue?" *Journal of Environmental Management.* 63:387-405.

Toman, Michael A., John Pezzey and Jeffrey Krautkraemer. 1995. "Neoclassical Economic Growth Theory and Sustainability." *In Handbook of Environmental Economics.* Bromley, Daniel W (ed). Blackwell Publishing. Oxford, United Kingdom: 139-166.

Toman, Micheal A. and Margaret Walls. 1995. "Non-renewable Resource Supply: Theory and Practice." *In Handbook of Environmental Economics.* Bromley, Daniel W (ed). Blackwell Publishing. Oxford, United Kingdom: 182-201.

Van den Bergh, Jeroen C.J.M. and Marjan W. Hofkes. 1999. Economic Models of Sustainable Development. *In Handbook of Environmental and Resource Economics.* Van den Bergh (ed). Edward Elgar Publishing, United Kingdom. 1108-1122.

Van Kooten, G. Cornelis and Henk Folmer. 2004. *Land and Forest Economics.* Edward Elgar Publishing Limited. United Kingdom.

Vincent, J.R., T. Panayotou and J. Hartwick. 1997. "Resource Depletion and Sustainability in Small Open Economies." *Journal of Environmental Economics* and Management 33(3): 274–286.

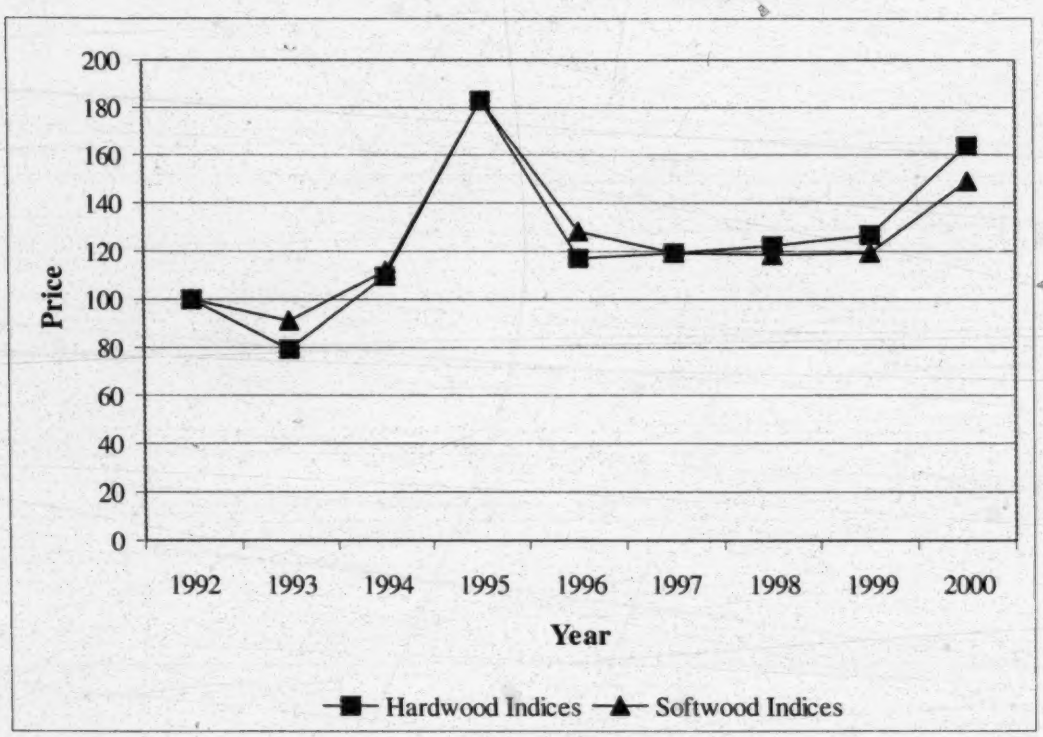
Vincent, Jeffrey R. 1999. "A Framework for Forest Accounting." *Forest Science.* 45(4): 552-561.

_____.2000. "Green Accounting: From Theory to Practice." *Environment and Development Economics.* 5: 13-24.

World Resources Institute. 2000. "Canada's Forests at a Crossroads: An Assessment in the Year 2000." *A Global Forest Watch Canada Report.* Washington D.C., U.S.A.

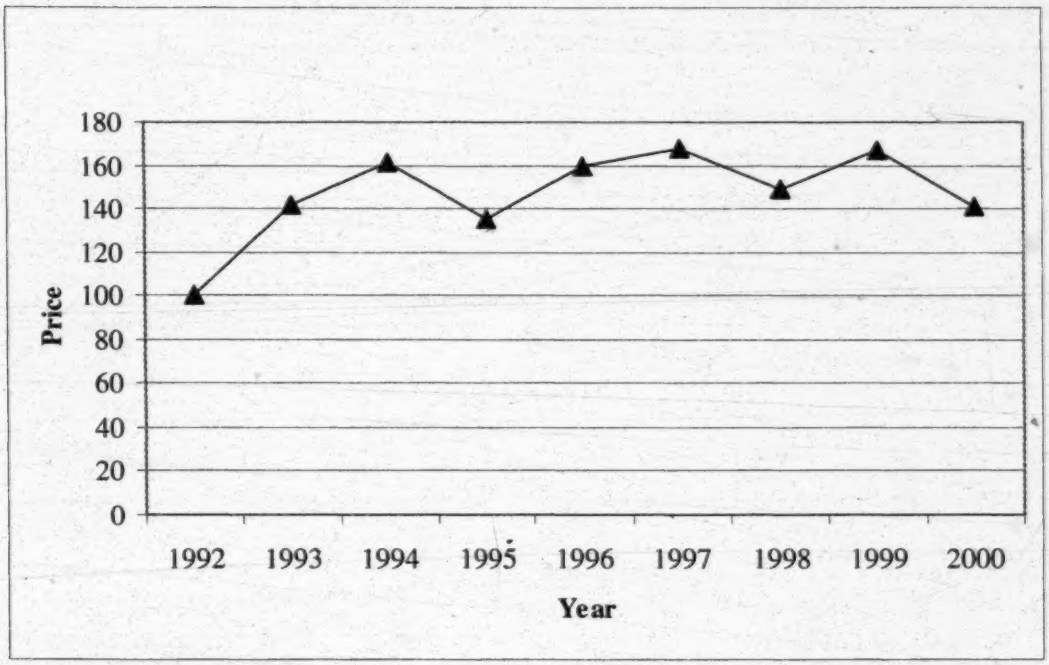
Wunder, Sven. 2003. *Oil Wealth and the Fate of the Forest: A Comparative Study of Eight Tropical Countries.* Routledge, Taylor and Francis Group. London, United Kingdom.

Appendix A
Industrial Product Indices for Pulp and Paper, (1992=100)



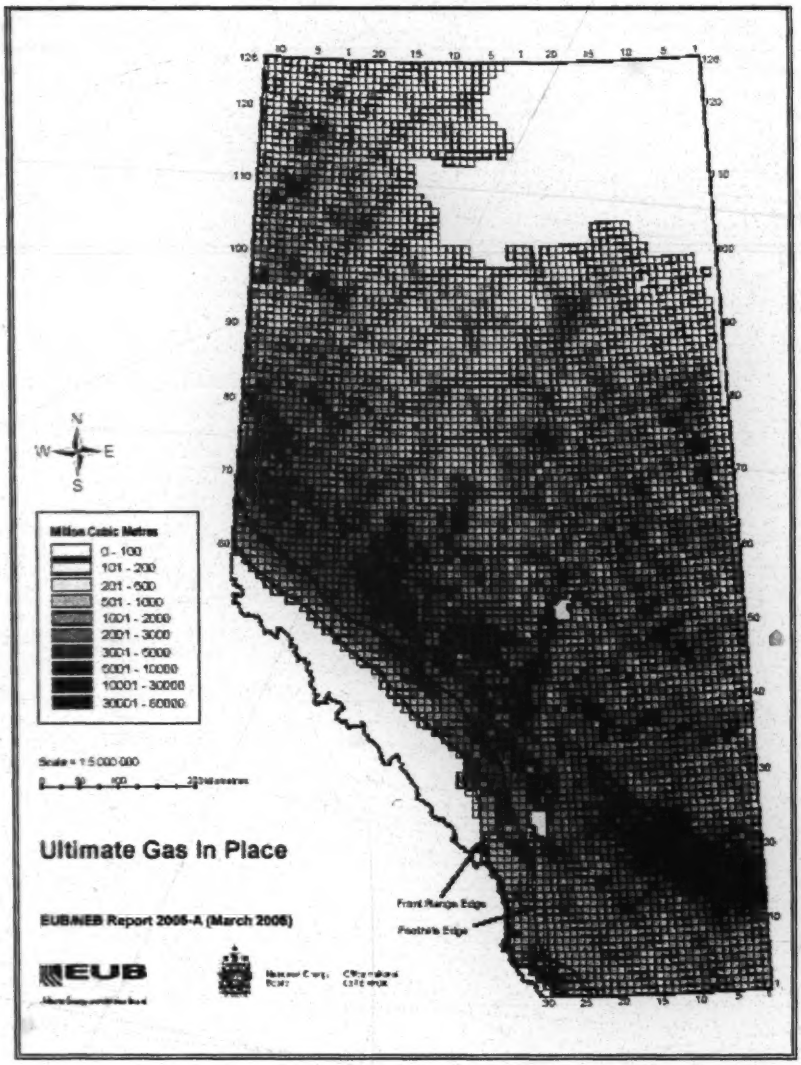
Source: CANSIM, Statistics Canada

Appendix B
Industrial Product Indexes for Lumber (1992=100)



Source: CANSIM, Statistics Canada

Appendix C
Sample of Thematic Map for Ultimate Natural Gas Potential for the Province of Alberta



Appendix Table 1. Fifteen-Year Timber Stock Physical Account for the Heart Lake First Nation Traditional Area (In Cubic Meters)

	2000		2001		2002		2003		2004	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4	8,484,000	5,209,000								
L5	5,079,000	4,089,000								
L6	18,696,000	7,088,000								
L7	*32,259,000*	*16,386,000*								
L1	16,879,000	8,060,000								
Total	**49,138,000**	**24,446,000**	**49,216,121**	**24,458,554**	**49,295,153**	**24,471,256**	**49,375,109**	**24,484,107**	**49,455,999**	**24,497,110**
Removals										
Al-Pac Harvest										
L4, L5, L6	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*
L1	*165,053*		*165,053*		*165,053*		*165,053*		*165,053*	
L4, L5, L6		*35,502*		*35,502*		*35,502*		*35,502*		*35,502*
L1		*21,869*		*21,869*		*21,869*		*21,869*		*21,869*
Quota Holder Harvest										
L4, L5, L6										
L1		*35,872*		*35,872*		*35,872*		*35,872*		*35,872*
CTPs										
L4, L5, L6		*15,000*		*15,000*		*15,000*		*15,000*		*15,000*
L1		*23,128*		*23,128*		*23,128*		*23,128*		*23,128*
Fire	1,081.04	537.81	1,082.75	538.09	1,084.49	538.37	1,086.25	538.65	1,088.03	538.94
Total	*496,794*	*275,909*	*496,796*	*275,909*	*496,797*	*275,909*	*496,799*	*275,910*	*496,801*	*275,910*
Additions										
Growth										
L4, L5, L6	377,430	193,355	575,829	288,611	576,753	288,761	577,689	288,912	578,635	289,066
L1	197,484	95,108								
Closing Stock	**49,216,121**	**24,458,554**	**49,295,153**	**24,471,256**	**49,375,109**	**24,484,107**	**49,455,999**	**24,497,110**	**49,537,833**	**24,510,266**
Net Change in Stock	**78,121**	**12,554**	**79,033**	**12,702**	**79,956**	**12,851**	**80,890**	**13,003**	**81,834**	**13,156**

Continuation.... Appendix Table 1.

	2005		2006		2007		2008		2009	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4										
L5										
L6										
L7										
L1										
Total	**49,537,833**	**24,510,266**	**49,620,623**	**24,523,577**	**49,704,379**	**24,537,045**	**49,789,114**	**24,550,671**	**49,874,838**	**24,564,458**
Removals										
Al-Pac Harvest										
L4, L5, L6	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000
L1	165,053		165,053		165,053		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869		21,869
Quota Holder Harvest										
L4, L5, L6										
L1		35,872		35,872		35,872		35,872		35,872
CTPs										
L4, L5, L6		15,000		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128		23,128
Fire	1,090	539	1,092	540	1,093	540	1,095	540	1,097	540
Total	**496,803**	**275,910**	**496,805**	**275,911**	**496,806**	**275,911**	**496,808**	**275,911**	**496,810**	**275,911**
Additions										
Growth										
L4, L5, L6	579,593	289,221	580,561	289,378	581,541	289,537	582,533	289,698	583,536	289,861
L1										
Closing Stock	**49,620,623**	**24,523,577**	**49,704,379**	**24,537,045**	**49,789,114**	**24,550,671**	**49,874,838**	**24,564,458**	**49,961,564**	**24,578,407**
Net Change in Stock	***82,790***	***13,311***	***83,757***	***13,468***	***84,735***	***13,626***	***85,724***	***13,787***	***86,725***	***13,949***

Continuation.... Appendix Table 1.

	2010		2011		2012		2013		2014	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4										
L5										
L6										
L7										
L1										
Total	**49,961,564**	**24,578,407**	**50,049,302**	**24,592,520**	**50,138,065**	**24,606,800**	**50,227,864**	**24,621,248**	**50,318,712**	**24,635,866**
Removals										
Al-Pac Harvest										
L4, L5, L6	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000
L1	165,053		165,053		165,053		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869		21,869
Quota Holder Harvest										
L4, L5, L6										
L1		35,872		35,872		35,872		35,872		35,872
CTPs										
L4, L5, L6		15,000		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128		23,128
Fire	1,099.15	540.72	1,101.08	541.04	1,103.04	541.35	1,105.01	541.67	1,107.01	541.99
Total	**496,812**	**275,912**	**496,814**	**275,912**	**496,816**	**275,912**	**496,818**	**275,913**	**496,820**	**275,913**
Additions										
Growth										
L4, L5, L6	584,550	290,025	585,577	290,192	586,615	290,360	587,666	290,531	588,729	290,703
L1										
Closing Stock	**50,049,302**	**24,592,520**	**50,138,065**	**24,606,800**	**50,227,864**	**24,621,248**	**50,318,712**	**24,635,866**	**50,410,621**	**24,650,656**
Net Change in Stock	*87,738*	*14,113*	*88,763*	*14,280*	*89,799*	*14,448*	*90,848*	*14,618*	*91,909*	*14,790*

Appendix Table 2. Timber Physical Account Using Actual Harvests Data on Deciduous Species for 1996-2009 (In Cubic Meters)

	1996		1997		1998		1999		2000	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4									8,484,000	5,209,000
L5									5,079,000	4,089,000
L6									18,696,000	7,088,000
Subtotal									32,259,000	16,386,000
L1									16,879,000	8,060,000
Total	**48,803,813**	**24,393,056**	**49,097,523**	**24,406,059**	**49,274,643**	**24,419,217**	**49,280,816**	**24,432,530**	**49,138,000**	**24,446,000**
Removals										
Al-Pac Harvest										
L4, L5, L6	222,664	144,000	454,649	144,000	615,068	144,000	667,092	144,000	585,159	144,000
L1	250,537		238,181		178,525		53,394		118,655	
L4, L5, L6		35,502		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869		21,869
Quota Holder Harvest										
L4, L5, L6										
L1		35,872		35,872		35,872		35,872		35,872
CTPs										
L4, L5, L6		15,000		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128		23,128
Fire	1,074	537	1,080	537	1,084	537	1,084	538	1,081	538
Total	**474,275**	**275,908**	**693,910**	**275,908**	**794,677**	**275,908**	**721,570**	**275,909**	**704,895**	**275,909**
Additions										
Growth										
L4, L5, L6	571,005	287,838	574,441	287,991	576,513	288,147	576,586	288,304	377,430	193,355
L1									197,484	95,108
Closing Stock	**48,902,690**	**24,406,059**	**48,980,214**	**24,419,217**	**49,058,648**	**24,432,530**	**49,138,000**	**24,446,000**	**49,008,020**	**24,458,554**
Net Change in Stock	**98,877**	**13,004**	**(117,309)**	**13,157**	**(215,996)**	**13,313**	**(142,816)**	**13,470**	**(129,980)**	**12,554**

Continuation.... Appendix Table 2.

	2001		2002		2003		2004	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4								
L5								
L6								
Subtotal								
L1								
Total	**49,008,020**	**24,458,554**	**48,794,260**	**24,471,256**	**48,841,808**	**24,484,107**	**48,916,469**	**24,497,110**
Removals								
Al-Pac Harvest								
L4, L5, L6	569,933	144,000	522,272	144,000	330,660	144,000	330,660	144,000
L1	216,142		-		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869
Quota Holder Harvest								
L4, L5, L6								
L1		35,872		35,872		35,872		35,872
CTPs								
L4, L5, L6		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128
Fire	1,078	538	1,073	538	1,075	539	1,076	539
Total	**787,153**	**275,909**	**523,345**	**275,909**	**496,788**	**275,910**	**496,789**	**275,910**
Additions								
Growth								
L4, L5, L6	573,394	288,611	570,893	288,761	571,449	288,912	572,323	289,066
L1								
Closing Stock	**48,794,260**	**24,471,256**	**48,841,808**	**24,484,107**	**48,916,469**	**24,497,110**	**48,992,003**	**24,510,266**
Net Change in Stock	**(213,759)**	**12,702**	**47,547**	**12,851**	**74,662**	**13,003**	**75,534**	**13,156**

Continuation…. Appendix Table 2.

	2005		2006		2007		2008		2009	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4										
L5										
L6										
Subtotal										
L1										
Total	**48,992,003**	**24,510,266**	**49,068,418**	**24,523,577**	**49,145,726**	**24,537,045**	**49,223,937**	**24,550,671**	**49,303,061**	**24,564,458**
Removals										
Al-Pac Harvest										
L4, L5, L6	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000
L1	165,053		165,053		165,053		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869		21,869
Quota Holder Harvest										
L4, L5, L6										
L1		35,872		35,872		35,872		35,872		35,872
CTPs										
L4, L5, L6		15,000		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128		23,128
Fire	1,078	539	1,080	540	1,081	540	1,083	540	1,085	540
Total	**496,791**	**275,910**	**496,793**	**275,911**	**496,794**	**275,911**	**496,796**	**275,911**	**496,798**	**275,911**
Additions										
Growth										
L4, L5, L6	573,206	289,221	574,100	289,378	575,005	289,537	575,920	289,698	576,846	289,861
L1										
Closing Stock	**49,068,418**	**24,523,577**	**49,145,726**	**24,537,045**	**49,223,937**	**24,550,671**	**49,303,061**	**24,564,458**	**49,383,109**	**24,578,407**
Net Change in Stock	**76,416**	**13,311**	**77,308**	**13,468**	**78,211**	**13,626**	**79,124**	**13,787**	**80,048**	**13,949**

Appendix Table 3. Timber Physical Account Using Backward Forecasting for Harvests for 1996-2009 (In Cubic Meters)

	1996		1997		1998		1999		2000	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4									8,484,000	5,209,000
L5									5,079,000	4,089,000
L6									18,696,000	7,088,000
Subtotal									*32,259,000*	*16,386,000*
L1									16,879,000	8,060,000
Total	**48,826,064**	**24,393,056**	**48,902,690**	**24,406,059**	**48,980,214**	**24,419,217**	**49,058,647.53**	**24,432,529.6**	**49,138,000**	**24,446,000**
Removals										
Al-Pac Harvest										
L4, L5, L6	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*	*330,660*	*144,000*
L1	*165,053*		*165,053*		*165,053*		*165,053*		*165,053*	
L4, L5, L6		*35,502*		*35,502*		*35,502*		*35,502*		*35,502*
L1		*21,869*		*21,869*		*21,869*		*21,869*		*21,869*
Quota Holder Harvest										
L4, L5, L6										
L1		*35,872*		*35,872*		*35,872*		*35,872*		*35,872*
CTPs										
L4, L5, L6		*15,000*		*15,000*		*15,000*		*15,000*		*15,000*
L1		*23,128*		*23,128*		*23,128*		*23,128*		*23,128*
Fire	1,074.17	536.65	1,075.86	536.93	1,077.56	537.22	1,079.290	537.52	1,081.04	537.81
Total	*496,787*	*275,908*	*496,789*	*275,908*	*496,791*	*275,908*	*496,792*	*275,909*	*496,794*	*275,909*
Additions										
Growth										
L4, L5, L6	571,265	287,838	572,161	287,991	573,069	288,147	573,986	288,304	377,430	193,355
L1									197,484	95,108
Closing Stock	**48,902,690**	**24,406,059**	**48,980,214**	**24,419,217**	**49,058,648**	**24,432,530**	**49,138,000**	**24,446,000**	**49,216,121**	**24,458,554**
Net Change in Stock	**76,626**	**13,004**	**77,524**	**13,157**	**78,433**	**13,313**	**79,352**	**13,470**	**78,121**	**12,554**

Continuation.... Appendix Table 3.

	2001		2002		2003		2004		2005	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4										
L5										
L6										
Subtotal										
L1										
Total	**49,216,121**	**24,458,554**	**49,295,153**	**24,471,256**	**49,537,833**	**24,510,266**	**49,455,999**	**24,497,110**	**49,537,833**	**24,510,266**
Removals										
Al-Pac Harvest										
L4, L5, L6	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000
L1	165,053		165,053		165,053		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869		21,869
Quota Holder Harvest										
L4, L5, L6										
L1		35,872		35,872		35,872		35,872		35,872
CTPs										
L4, L5, L6		15,000		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128		23,128
Fire	1,083	538	1,084	538	1,090	539	1,088	539	1,090	539
Total	**496,796**	**275,909**	**496,797**	**275,909**	**496,803**	**275,910**	**496,801**	**275,910**	**496,803**	**275,910**
Additions										
Growth										
L4, L5, L6	575,829	288,611	576,753	288,761	579,593	289,221	578,635	289,066	579,593	289,221
L1										
Closing Stock	**49,295,153**	**24,471,256**	**49,375,109**	**24,484,107**	**49,620,623**	**24,523,577**	**49,537,833**	**24,510,266**	**49,620,623**	**24,523,577**
Net Change in Stock	**79,033**	**12,702**	**79,956**	**12,851**	**82,790**	**13,311**	**81,834**	**13,156**	**82,790**	**13,311**

Continuation.... Appendix Table 3.

	2006		2007		2008		2009	
Opening Stock	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**	**Deciduous**	**Coniferous**
L4								
L5								
L6								
Subtotal								
L1								
Total	**49,620,623**	**24,523,577**	**49,704,379**	**24,537,045**	**49,789,114**	**24,550,671**	**49,874,838**	**24,564,458**
Removals								
Al-Pac Harvest								
L4, L5, L6	330,660	144,000	330,660	144,000	330,660	144,000	330,660	144,000
L1	165,053		165,053		165,053		165,053	
L4, L5, L6		35,502		35,502		35,502		35,502
L1		21,869		21,869		21,869		21,869
Quota Holder Harvest								
L4, L5, L6								
L1		35,872		35,872		35,872		35,872
CTPs								
L4, L5, L6		15,000		15,000		15,000		15,000
L1		23,128		23,128		23,128		23,128
Fire	1,092	540	1,093	540	1,095	540	1,097	540
Total	**496,805**	**275,911**	**496,806**	**275,911**	**496,808**	**275,911**	**496,810**	**275,911**
Additions								
Growth								
L4, L5, L6	580,561	289,378	581,541	289,537	582,533	289,698	583,536	289,861
L1								
Closing Stock	**49,704,379**	**24,537,045**	**49,789,114**	**24,550,671**	**49,874,838**	**24,564,458**	**49,961,564**	**24,578,407**
Net Change in Stock	**83,757**	**13,468**	**84,735**	**13,626**	**85,724**	**13,787**	**86,725**	**13,949**

Appendix Table 4. Changes in Economic Values Associated with Changes in Clear Cutting Activities Given Different Number of Hunting Sites Available

Period	Change Per Trip		Total Change Per Year	
	CV1 (Base)	CV2 (5-Year changes)	CV1 (Base)	CV2 (5-Year changes)
	83 Hunting Areas Available			
1991-1995	-0.55	-0.55	-719.18	-719.18
1996-2000	0.02	0.57	19.63	738.80
2001-2005	0.26	0.24	338.07	318.44
2006-2010	0.25	-0.01	328.10	-9.97
2011-2015	0.22	-0.03	283.37	-44.73
	62 Hunting Areas Available			
1991-1995	-0.51	-0.51	-657.78	-657.78
1996-2000	0.11	0.61	137.81	795.58
2001-2005	0.29	0.19	379.37	241.56
2006-2010	0.33	0.04	433.86	54.49
2011-2015	0.28	-0.06	361.06	-72.80
	41 Hunting Areas Available			
1991-1995	-0.34	-0.34	-441.19	-441.19
1996-2000	0.36	0.70	465.03	906.23
2001-2005	0.39	0.03	502.00	36.97
2006-2010	0.47	0.08	611.04	109.04
2011-2015	0.39	-0.08	501.46	-109.59
	21 Hunting Areas Available			
1991-1995	-0.28	-0.28	-365.65	-365.65
1996-2000	0.37	0.66	486.34	851.99
2001-2005	0.18	-0.19	237.41	-248.93
2006-2010	0.19	0.01	249.99	12.58
2011-2015	0.32	0.13	420.90	170.91

Appendix Table 5. Total Value for Gas Production in the Study Area

Period	Annual gas e3m3	Ultimate Potential e3m3	Remaining e3m3	Price $Cdn/e3m3	Average Cost $Cdn/e3m3	Opening Stocks Ultimate Potential	Rate of Return
1997	93,491	133,184,691	133,091,201	61	17	133,184,691	0.10
1998	95,949	137,278,456	137,182,506	69	17	137,278,456	0.10
1999	80,845	141,197,756	141,116,910	98	20	141,197,756	0.10
2000	87,413	146,210,276	146,122,863	186	18	146,210,276	0.10
2001	93,722	150,289,543	150,195,821	77	18	150,289,543	0.10
2002	80,577	154,948,519	154,867,942	118	19	154,948,519	0.10
2003	67,577	158,016,499	157,948,922	223	18	158,016,499	0.10
2004	58,015	163,662,000	163,603,986	140	18	163,662,000	0.10
2005	75,601	168,050,187	167,974,586	365	19	168,050,187	0.10
2006	77,802	164,689,184	164,611,381	427	18	164,689,184	0.10
2007	80,645	161,395,400	161,314,755	410	18	161,395,400	0.10
2008	83,698	158,167,492	158,083,794	388	18	158,167,492	0.10
2009	82,236	155,004,142	154,921,906	367	18	155,004,142	0.10
2010	81,352	151,904,059	151,822,708	348	18	151,904,059	0.10
2011	80,418	148,865,978	148,785,560	382	18	148,865,978	0.10
2012	79,223	145,888,659	145,809,435	373	18	145,888,659	0.10
2013	79,098	142,970,885	142,891,787	369	18	142,970,885	0.10
2014	78,459	140,111,468	140,033,009	369	18	140,111,468	0.10
2015	77,285	137,309,238	137,231,954	371	18	137,309,238	0.10

Continuation.... Appendix Table 5.

Period	Value of Associated Capital ($Cdn)	Total Quantity e3m3	Rate of Depreciation	Total Value * $Cdn	Total Rent ** $Cdn/e3m3	Total Rent $Cdn/m3
1997	15,071,230	93,491	0.10	1,662,670,076	44	0.04
1998	9,499,653	95,949	0.06	4,978,996,089	52	0.05
1999	2,455,227	80,845	0.12	10,018,303,957	78	0.08
2000	21,557,358	87,413	0.16	15,240,001,566	168	0.17
2001	7,076,505	93,722	0.16	5,910,744,240	59	0.06
2002	8,015,446	80,577	0.17	11,279,637,115	99	0.10
2003	15,722,372	67,577	0.05	26,732,959,998	204	0.20
2004	7,771,147	58,015	0.10	15,570,903,688	122	0.12
2005	28,369,961	75,601	0.15	42,173,912,868	346	0.35
2006	33,832,132	77,802	0.07	55,290,602,136	408	0.41
2007	31,068,067	80,645	0.08	51,999,005,788	391	0.39
2008	29,388,286	83,698	0.06	49,815,771,194	370	0.37
2009	27,537,039	82,236	0.05	45,976,884,589	348	0.35
2010	25,343,402	81,352	0.07	42,025,556,619	330	0.33
2011	27,635,812	80,418	0.08	45,132,510,081	364	0.36
2012	27,309,340	79,223	0.05	44,058,967,822	354	0.35
2013	27,776,929	79,098	0.08	40,835,858,790	350	0.35
2014	27,642,295	78,459	0.09	39,723,084,142	351	0.35
2015	27,658,487	77,285	0.12	37,835,749,477	353	0.35

Note: * - Total value is estimated using the formula presented in **Equation [33]**.
**- Rent is difference between Price and Average Cost.